

of
en
on
al
as
e
g
s-
d-
s
s,
n
e
y
s
e
-
a
s
i

e

1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
 32
 33
 34
 35
 36
 37
 38
 39
 40
 41
 42
 43
 44
 45
 46
 47
 48
 49
 50
 51
 52
 53
 54
 55
 56
 57
 58
 59
 60
 61
 62
 63
 64
 65
 66
 67
 68
 69
 70
 71
 72
 73
 74
 75
 76
 77
 78
 79
 80
 81
 82
 83
 84
 85
 86
 87
 88
 89
 90
 91
 92
 93
 94
 95
 96
 97
 98
 99
 100
 101
 102
 103
 104
 105
 106
 107
 108
 109
 110
 111
 112
 113
 114
 115
 116
 117
 118
 119
 120
 121
 122
 123
 124
 125
 126
 127
 128
 129
 130
 131
 132
 133
 134
 135
 136
 137
 138
 139
 140
 141
 142
 143
 144
 145
 146
 147
 148
 149
 150
 151
 152
 153
 154
 155
 156
 157
 158
 159
 160
 161
 162
 163
 164
 165
 166
 167
 168
 169
 170
 171
 172
 173
 174
 175
 176
 177
 178
 179
 180
 181
 182
 183
 184
 185
 186
 187
 188
 189
 190
 191
 192
 193
 194
 195
 196
 197
 198
 199
 200
 201
 202
 203
 204
 205
 206
 207
 208
 209
 210
 211
 212
 213
 214
 215
 216
 217
 218
 219
 220
 221
 222
 223
 224
 225
 226
 227
 228
 229
 230
 231
 232
 233
 234
 235
 236
 237
 238
 239
 240
 241
 242
 243
 244
 245
 246
 247
 248
 249
 250
 251
 252
 253
 254
 255
 256
 257
 258
 259
 260
 261
 262
 263
 264
 265
 266
 267
 268
 269
 270
 271
 272
 273
 274
 275
 276
 277
 278
 279
 280
 281
 282
 283
 284
 285
 286
 287
 288
 289
 290
 291
 292
 293
 294
 295
 296
 297
 298
 299
 300
 301
 302
 303
 304
 305
 306
 307
 308
 309
 310
 311
 312
 313
 314
 315
 316
 317
 318
 319
 320
 321
 322
 323
 324
 325
 326
 327
 328
 329
 330
 331
 332
 333
 334
 335
 336
 337
 338
 339
 340
 341
 342
 343
 344
 345
 346
 347
 348
 349
 350
 351
 352
 353
 354
 355
 356
 357
 358
 359
 360
 361
 362
 363
 364
 365
 366
 367
 368
 369
 370
 371
 372
 373
 374
 375
 376
 377
 378
 379
 380
 381
 382
 383
 384
 385
 386
 387
 388
 389
 390
 391
 392
 393
 394
 395
 396
 397
 398
 399
 400
 401
 402
 403
 404
 405
 406
 407
 408
 409
 410
 411
 412
 413
 414
 415
 416
 417
 418
 419
 420
 421
 422
 423
 424
 425
 426
 427
 428
 429
 430
 431
 432
 433
 434
 435
 436
 437
 438
 439
 440
 441
 442
 443
 444
 445
 446
 447
 448
 449
 450
 451
 452
 453
 454
 455
 456
 457
 458
 459
 460
 461
 462
 463
 464
 465
 466
 467
 468
 469
 470
 471
 472
 473
 474
 475
 476
 477
 478
 479
 480
 481
 482
 483
 484
 485
 486
 487
 488
 489
 490
 491
 492
 493
 494
 495
 496
 497
 498
 499
 500
 501
 502
 503
 504
 505
 506
 507
 508
 509
 510
 511
 512
 513
 514
 515
 516
 517
 518
 519
 520
 521
 522
 523
 524
 525

Here's Your PRODUCTION AID

The RYERSON
1942 STOCK LIST



1942-43 RYERSON STEELS

*Certified
Quality*



JOSEPH T. RYERSON & SON, INC.

Ryerson again assembles complete and helpful listings of more than 10,000 steel sizes and shapes...puts comprehensive information at your fingertips...helps you order steel. This new 1942 Ryerson Stock List is engineered for convenience—quick—new tab-indexed, handy pocket size, crammed full of facts that will make it a steel buyer's "book of knowledge."

Even though many kinds of steel cannot always be delivered promptly, because of war demands, you can depend on Ryerson to help you; to work with you on your steel problems; to give you the best service possible in keeping with government regulations.

Make this 100th Anniversary Ryerson Stock List your guide—use it. If you have not received your copy, write your nearest Ryerson plant. Joseph T. Ryerson & Son, Inc., Chicago, Milwaukee, St. Louis, Cincinnati, Detroit, Cleveland, Buffalo, Philadelphia, Boston, Jersey City.

RYERSON *Certified* **STEELS**





Ingots, risers, and a sprinkling of flux



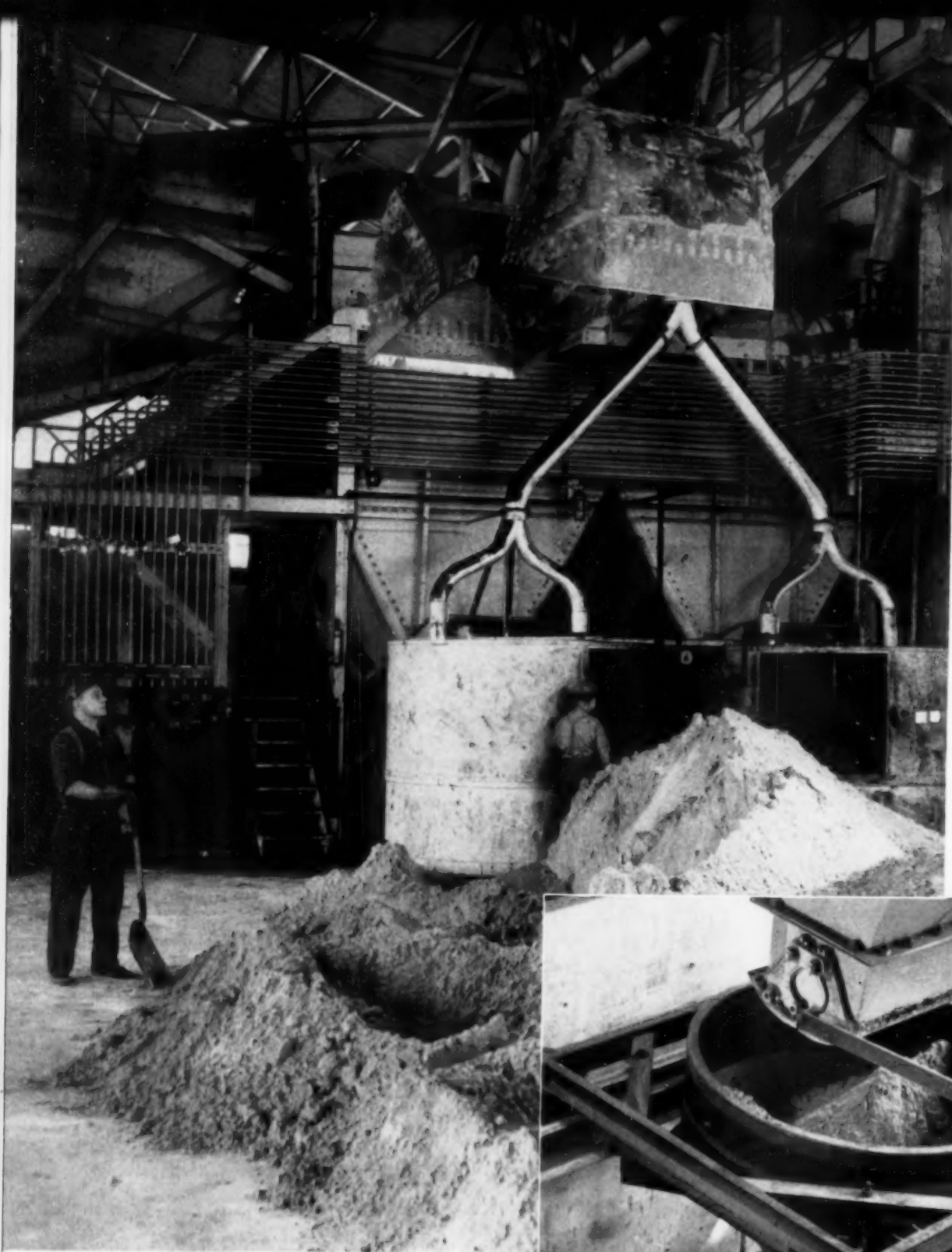
*come out as
landing wheels
for America's aircraft*

Magnesium Foundry

Photographed by

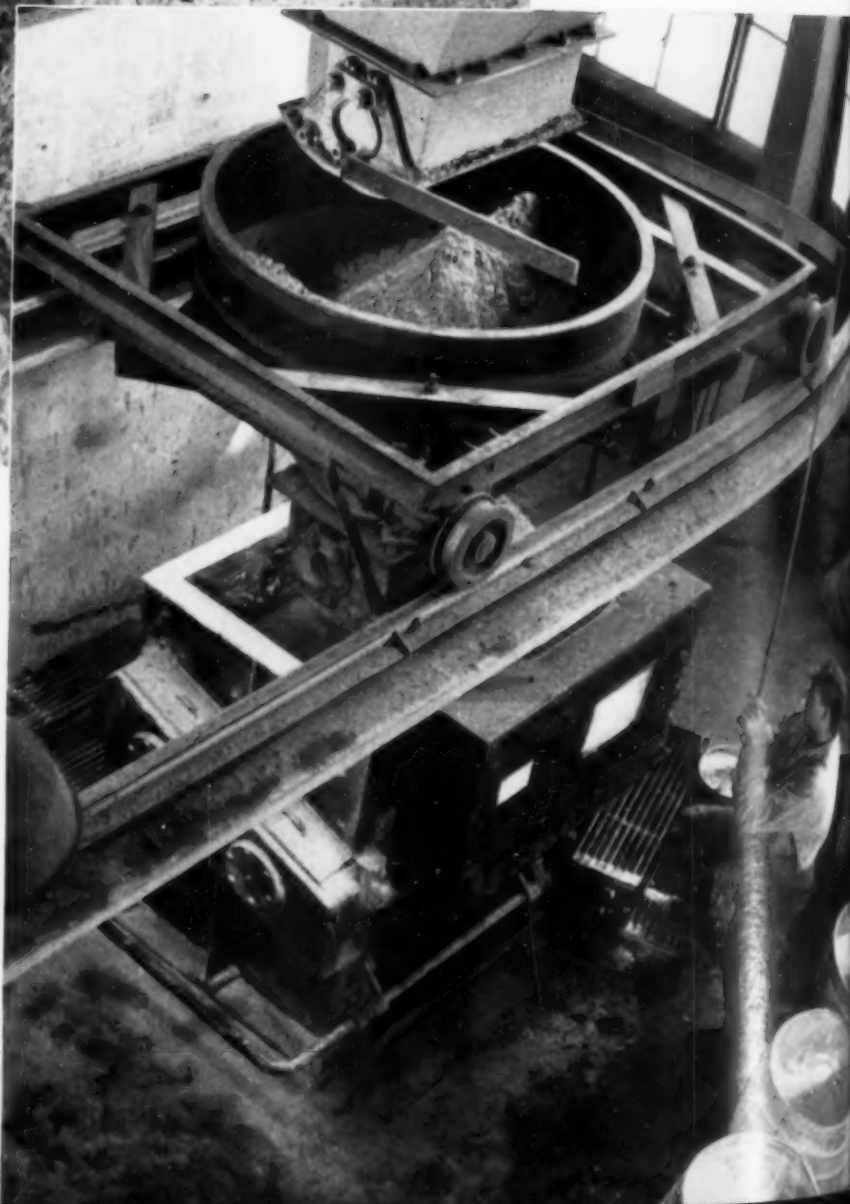
H. B. Cornelius

(Courtesy
The Dow Chemical
Company)



BOTH molding sand and core sand arrive in boxcars and trucks, to be stored under roof in generous bins, later tested, formulated, mixed and aerated. Man in background is attending one of two mullers, each in its cylindrical casing, for mixing molding sand. Photo at right is crane-man's view of preparation unit for core sand.

Page 492

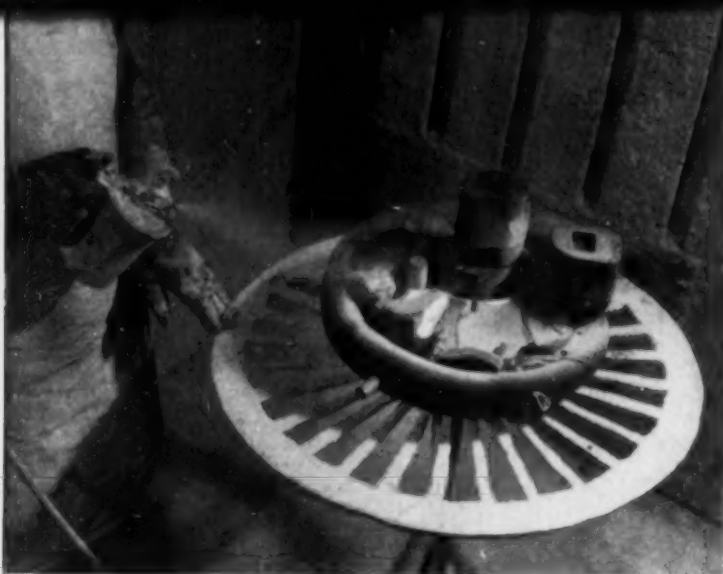


THE BEST WAY to get that open structure in molds and cores required to vent gases usually rapidly ahead of the light metal magnesium is to use synthetic sand. Successful molding is done with washed silica sand (20 to 80 grain size by American Foundrymen's Association test) mulled with 4% bentonite for bond, and 4% water (total). To check evaporation, some foundries add 1% ethylene glycol. A reagent must also be added to inhibit the reaction between the molten magnesium, as it enters the mold, and the moisture in the sand, and for this purpose a mixture of boric acid, sulphur and ammonium silico-fluoride will serve; quantity ranges from 4 to 10%, going up as the permeability of the sand goes down and the size of the casting goes up. . . . Above quantities are for all-new sand, and for make-up sand added to foundry returns. Some inhibiting agent burns out in use and must be replaced; frequent chemical analyses are necessary to keep conditions constant.

CORE SANDS also are open, sharp sands, carefully formulated by weighing portions of coarse and fine, adding measures of various binders and inhibitors, and mixing — all as shown in the view at left, below. Core oil that forms a minimum of gas should be chosen. Inhibitors are also necessary. A typical formula is: 1000 parts sand, core oil 12 parts, dextrine binder 8 parts, 13 parts sulphur, and powdered boric acid 13 parts, all by volume. Properties are a fine balance between high permeability to vent gas, chemical inertness to prevent oxidation of the hot magnesium, and sufficient tensile strength to hold against molten metal. Internal cores must also be friable enough to crack before the cooling and shrinking casting does — also to be easily washed out or shaken out in the cleaning room.

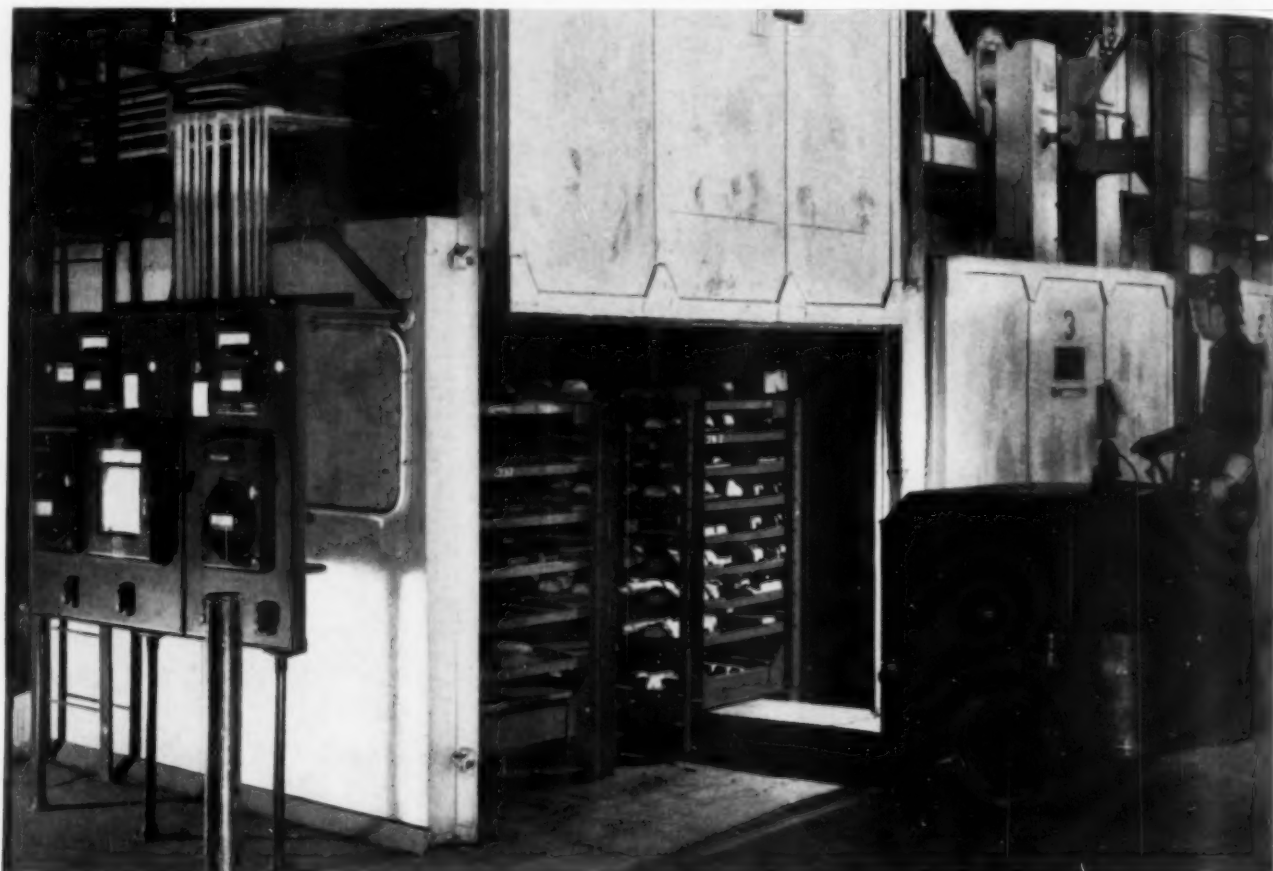


Core making is a fine art, either when the core is a thin plate made by hand in a wooden box, or a complicated set of spokes made in a roll-over machine with metal patterns. Note the vertical chill blocks of iron in the big core.



CORE MAKING and storage are most important. Surfaces to be pasted together should first be shellacked. Patching can be done with mixture of 1 part talc to 3 parts 200-mesh sand, to which is added 2% sulphur and 2% loric acid, then worked into a paste with alcohol and oil. For a smoother surface, and to prevent condensation on chills, cores are sprayed with talc suspended in alcohol containing 1 oz. resin per gallon. Storage rooms must be at 100° F. to prevent condensation of moisture from the atmosphere.

Dimensional Accuracy and Strength Require Accurate Baking up to 6 Hr. at 450° F.

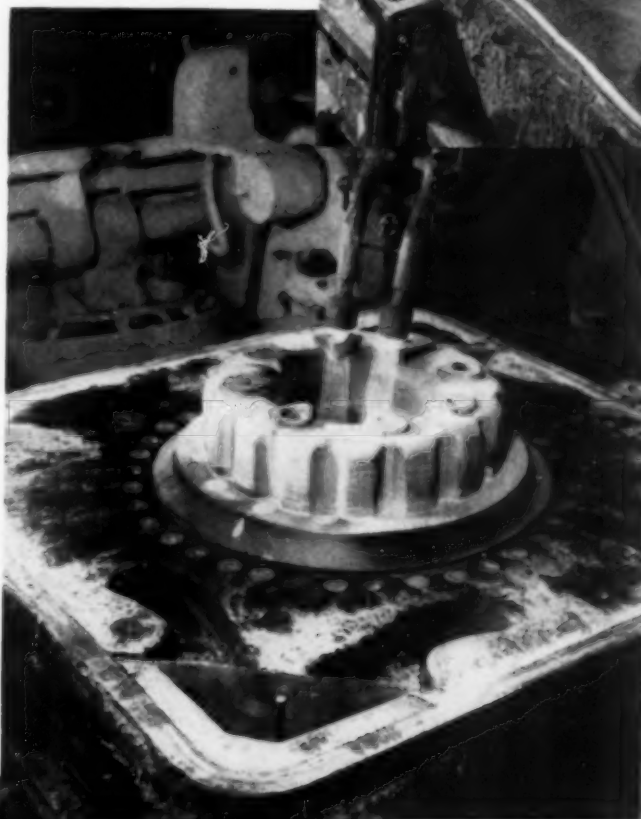


Vents in Deep Cores Are Inspected; Gas Must Go Through Sand Rather Than Blow Through Light Metal

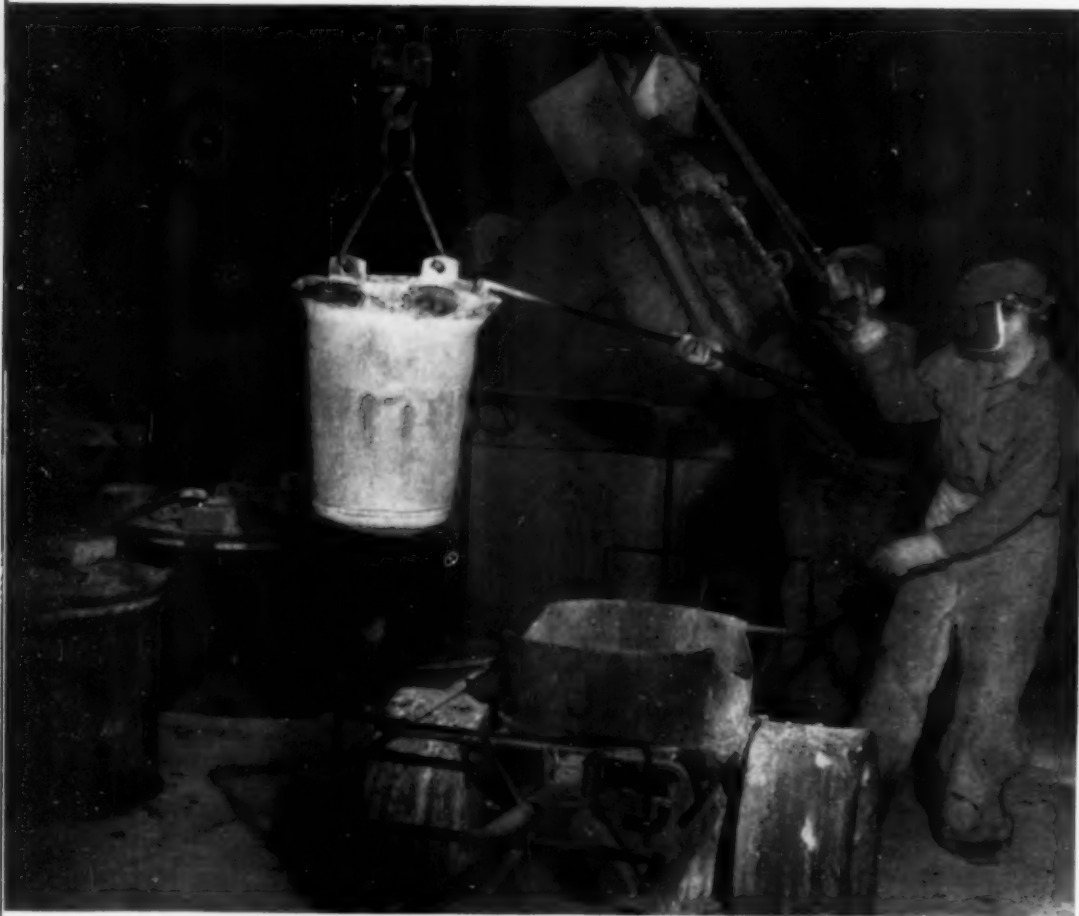
Baked Cores Are Rubbed to Accurate Size in Steel



TRIO of photographs of molds for a large landing wheel, made in three-part flasks. At bottom the molder is setting small iron chills around a core print, against what will be the wheel's rim. Note print for skim gate at upper left of the lowest picture. In the central picture a steel screen has been placed in the gate to filter out trapped oxide and to break up eddy currents in the inflowing metal. Metal turbulence, to be avoided at all costs, is further guarded against by bringing metal into the mold cavity at the lowest point, often by a ring runner and a series of finger gates equally spaced around the circumference.

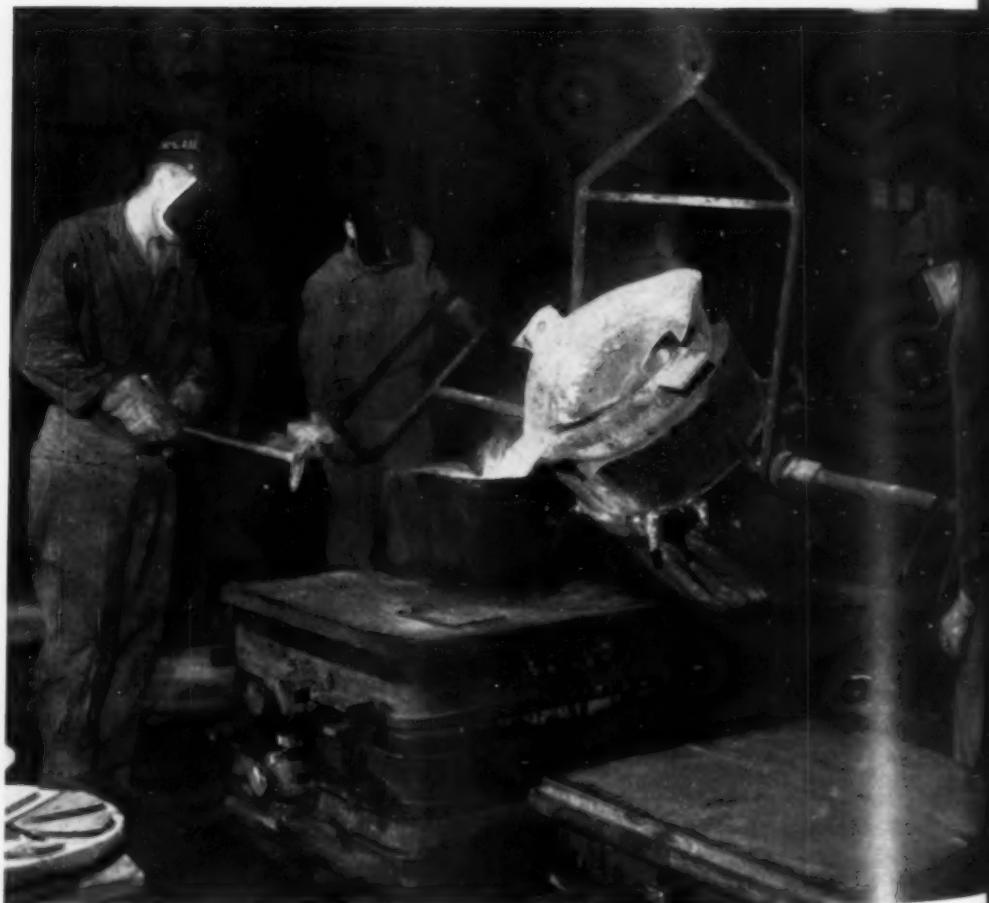


THIS middle view shows one core set in the drag. Occasionally certain portions need to be sprayed with alcohol and talc, and all liquid must then be evaporated with a gas flame. In the top view all cores and the cheek await placement of cope. Fine sand made into paste with a low volatile lubricating oil is squirted out in a "rope" around edges of parting lines to prevent the very liquid metal from running out or producing thin fins. . . . Pouring basin and other conditions are so arranged that sprues may be completely filled as quickly as possible after pouring starts.



ABOUT a ton of metal is melted in the large furnace in the background (shown in tilted position), brought to 1300° F., additional fresh flux spread over the melt and stirred, whereupon the oxide particles sink to the bottom. (Flux is a mixture of low melting point chlorides.) When the molten pool has a clear silvery luster it is transferred in 175-lb. lots to smaller crucibles, each to its own furnace setting, again well covered with flux, and superheated to 1650° F. to refine the grain of the casting. Satisfactory crucibles are of welded flange steel plate, aluminum coated outside by sandblasting and immersing in molten aluminum at 1500° F. for 20 min. All oxide and dross must be cleaned out of these pots before recharging.

CORRECT pouring temperature depends on alloy, thickness and weight of casting, and may be as low as 1400° F. Hot metal buggies are handy for transportation . . . Mold covers of sheet metal keep dirt out of risers. Generous pouring basins provide uniform and quiet flow into sprues. Covers are removed as soon as risers are chilled on top, and a little dry sand spread on two or three minutes later.





N UMEROUS cleaning operations are no different than in other non-ferrous foundries. Sand from cored holes is conveniently washed out by "hydroblast" (a water-sand blast), and castings then oven-dried. Sprues, gates, runners and risers bulk even larger than the shorn casting, and are best cut off by a mile-a-minute band saw with coarse teeth. Coarse dry saw scruff is swept up frequently and stored in covered steel kegs until remelted. Face screens and fire-resistant gloves are worn generally during casting, pouring or high speed machining; men should also wear smooth clothing and dust themselves off frequently. Proper equipment to snuff out fires must always be convenient; likewise wood must be exiled from the premises, because burning magnesium can get its oxygen from cellulose. . . . After rough machining to remove riser stubs the casting is pickled to accentuate surface imperfections. Buffing (as shown at right) must be done in booths with a powerful air exhaust to draw the metal particles down into a niagara of water. Grinders and sanders must also be exhausted into a spray tank. Such sludge cannot be reclaimed; mix it with earth and bury it.



MAGNESIUM aircraft and engine castings, being articles on which no pains are spared to secure highest quality, are subject to many auxiliary operations. Castings are heat treated and aged during a precisely controlled temperature cycle to get the requisite combination of strength and toughness. (A prepared furnace atmosphere containing 0.5% SO_2 will prevent surface oxidation.) Pressure-tight castings are warmed in a vacuum, impregnated with tung oil, and cooked in engine oil at 500° F. to polymerize the absorbed oil into a solid. Various chemical treatments have been devised to improve corrosion resistance, or to provide tooth for protective paints.



FINAL INSPECTION is proportionately searching. Dimensions are carefully checked, and the entire piece is searched for any visual defect. Numerous castings are chosen, at random, for X-ray examination, not only to establish correct foundry practice but to insure that it is maintained. Likewise occasional samples are cut apart and an expert lay-out man checks web thicknesses and scribes all principal lines and dimensions on the surfaces so exposed, to make sure that patterns are correct and the assembly of cores has not shifted.



War Products Consultation

Strategic Materials Used in Type Metal

The Problem

*As viewed by an executive
of a newspaper chain*

THE FIRM which supplies us with linotype and stereotype metal has informed us that a shortage of tin is impending, and this will probably affect the entire printing industry. We use a standard formula of $3\frac{3}{4}\%$ tin, $11\frac{1}{2}\%$ antimony, the remainder lead, in our typesetting machines. For casting semi-cylindrical stereotype plates used on rotary high speed presses, we use $4\frac{1}{2}\%$ tin, 13% antimony, the remainder lead. This metal is supplied to us on an arrangement whereby we ship all dross and take in return an equal tonnage of new metal. In 1941 we purchased 200,000 lb., but as our circulation is about 5% of the total newspaper circulations in the United States, we would judge that the annual requirements for newspapers would be on the order of 2000 tons of metal per year containing 80 tons (160,000 lb.) of tin. If the requirements of job printers, and book and magazine publishers are included, the needed tonnage must be considerable.

Loss of tin in drossage in melting pots is largely responsible for our purchase of new metal. Stereotype pots, where the bulk of this metal is used, run in capacity from 5 to 20 tons. Pouring temperature is approximately 600° F. Is there any possibility that silver could be substituted for some of the tin, or bismuth for the antimony?

The Suggested Solution

WHILE SILVER is a successful ingredient in substitute solders, one prime essential of type metal is hardness, and silver is not a good hardener for lead. Bismuth seems to be a more promising ingredient. However, metallurgical science has not yet advanced to the place where one could make any positive prediction as to what the effect of such a substituti-

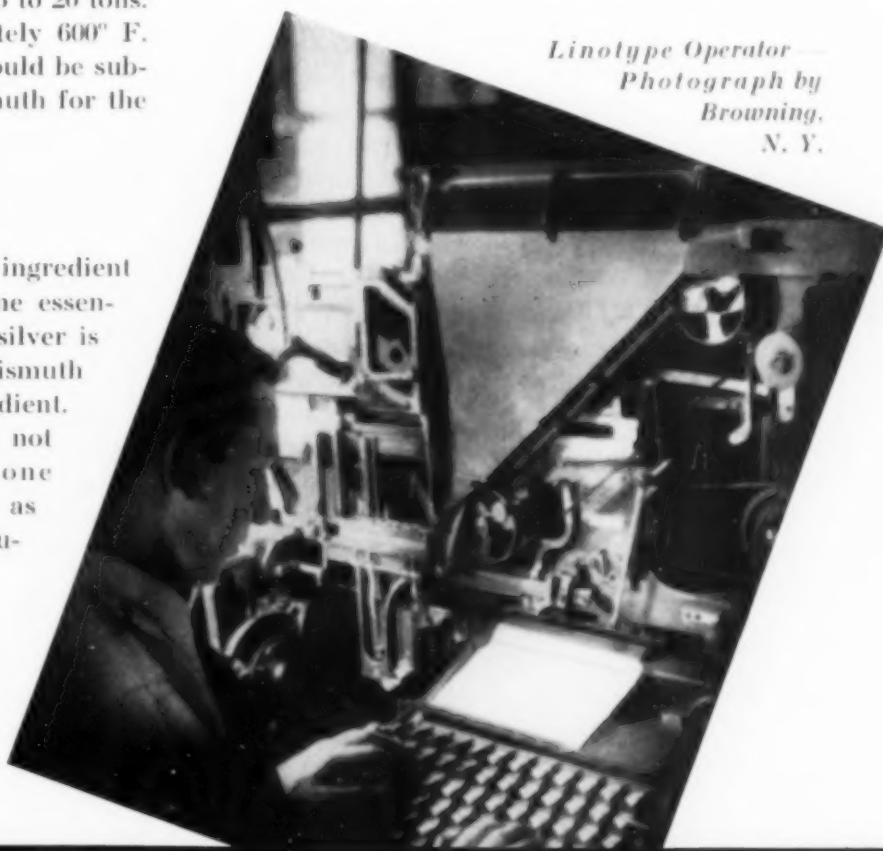
tion would be on metals whose casting characteristics are so critical as linotype and stereotype metal.

Detailed statistics for use of tin in 1937 show that about 450,000 lb. of primary tin was used for type metal during the year, plus about five times as much "secondary tin", presumably recovered from drosses. It is probable that much of this was absorbed into "standing type", for there should be small loss in the recovery of metal from the drosses. In other words, very little if any metal is actually *consumed* in the printing business; the type held standing in storage against second editions constitutes an important reserve in the printers' hands that can be drawn upon to keep the circulating metal up to analysis and, indeed, to recover some antimony and tin for other important war uses.

Dross (oxide) is produced not so much in remelting the metal as when casting and using the type. Melting pot dross could probably be reduced in quantity by a protective layer of high flash point oil on the molten metal.

Since any considerable substitution of one metal for another usually causes a shortage in the substitute, one should also consider the *supply* of bismuth. Bismuth is a byproduct of lead refining, the metal occurring naturally in the

*Linotype Operator —
Photograph by
Browning,
N. Y.*



ore. Its production, therefore, varies with lead production, and is now on the order of 2½ to 3 million pounds annually. A few years back it was more or less a drug on the market, but more recently large amounts have been absorbed in "matrix" alloys — low melting metals for grouting or backing-up dies in holders, and fixing finished bearings into journal boxes. It is also an ingredient of some of the new solders. Assuming that as much bismuth could be absorbed into type metal as the *new* tin used in 1937, the 450,000 lb. would probably lick up the visible supply of bismuth in short order.

Critique by Martin Seyt

Research Department, Plumbine Smelting Co.

THE ANALYSES for linotype metal and stereotype metal quoted by the newspaper official appear already to be quite economical in the strategic metal tin, both of them containing substantially less than the amount specified by the Government Printing Office for its requirements. Consequently the chance for further saving of tin is not too good. Type metal has been slowly developed, by cut and fit, to meet the diverse and specialized requirements of the printers — and, on the other hand, the typesetting machines have been adjusted to the available type metal alloys. Substitution of any other alloy would in all probability be unsatisfactory to the machine, no matter how fine the properties of the new composition. We have therefore contented ourselves in merely accentuating certain very desirable properties and suppressing the undesirable properties of the standard type metal.

I doubt if any of the lead-bismuth alloys will have the proper hardness range. They will have the low melting points desirable and it is quite conceivable that a lead-bismuth-antimony alloy could be worked up that had the correct hardness and melting point, but probably would lack the casting characteristics for linotype metal.

WALTER SMITH informs me that he, with J. G. THOMPSON at the National Bureau of Standards, some years ago studied the effect of bismuth additions to type metals. In general they found that the addition of up to about 2% bismuth to stereotype metal had little effect on the metal except to improve its casting properties and to slow down its solidification rate. This metal could also be used in linotype machines, but necessitated slower casting rates or some additional cooling. Addition of more than 2% bismuth very definitely softened the type metals

and reduced their wearing properties. Therefore bismuth would not be an effective substitute for antimony in type metals unless some other hardener is added.

The lead-antimony-silver alloys at first glance would appear to be more promising, although here the cost factor looms large. Nevertheless you will not quite succeed in getting the melting point low enough to make it a very satisfactory type metal. In addition there is a tendency for the silver-antimony to dissolve very slowly upon melting, and consequently the tendency to form silver-antimony dross might be quite serious with high speed machinery. Surprisingly enough we find that it is impossible to obtain the hardness values desired, undoubtedly due to the silver-antimony complex formed, and this is probably the most serious objection of all. Even 3% silver increases the hardness of lead-antimony alloys only one Brinell number.

Tinning of

"Difficult" Steels

By W. E. Hoare and H. Plummer

Extracts from Publication No. 107
Tin Research Institute

IT HAS BEEN FOUND convenient to classify mild steels as follows as regards their ability to produce a smooth, even coating: (a) "Normal", needing only a simple degreasing treatment followed by normal pickling; (b) "subnormal", needing a modified or intensified degreasing treatment followed by normal pickling, and (c) "difficult", needing special preparation or else the liquid will "de-wet", draw up into streaks or globules like the water on a window glass after a summer shower.

1. Tin mill black plate and sheet made by the hot-pack process generally exhibit "normal" tinning quality.

2. Tin mill black plate made by cold reduction of strip is generally "normal".

3. Sheet and strip made by cold reduction and temper-rolled or skin-passed with the use of rolling lubricants may sometimes show only "subnormal" tinning quality.

4. Sheet and strip cold reduced with lubricants and annealed without an intermediate degreasing operation may (Continued on page 590)

Further Alloy Conservation Needed in Heat Resistant Castings

WAR PRODUCTION BOARD, after adding up the tonnage for chromium and nickel requested for March delivery for pressing national needs, and finding that the figures were already greater than the amount of these two metals available in March, noting the increasing trend of demand, and viewing with some little apprehension the problem of building synthetic rubber, high octane gas, and magnesium plants, did the obvious thing and called a conference in Cleveland on March 31 of principal consumers of high alloy to find out where economies could be made. The chairman, GEORGE B. WATERHOUSE, executive consultant to the chief of the Metallurgical Section (Iron and Steel Branch) W.P.B., explained the urgency of the situation. Our large "normal" use of chromium in the high chromium-nickel stainless steels for decorative trim on automobiles, bars, and dog wagons has been entirely discontinued, but some 30% of the low carbon and 20% of the high carbon ferrochrome goes to foundries making heat and corrosion resistant castings. These are consumed by the petroleum, industrial furnace, chemical, and metallurgical industries (roughly in order of their importance). Demands are constantly growing, what with the large programs of new construction, and the larger maintenance of existing equipment pressed to capacity. Extraordinary new demands must also be met in the remaining months of 1942; for instance, some 5400 long tubular retorts, each taking 800 lb. of 35% Ni, 15% Cr, have been requested to equip the new magnesium plants operating on the Pidgeon ferrosilicon process (see last month's METAL PROGRESS, page 341) and their life is expected to be six months.

To arrive at specific recommendations the group then split into three, one the petroleum engineers, another the industrial furnace builders, and the third the alloy foundrymen. In the petroleum meeting it was pointed out that most of the high alloy is used in tubular and other wrought forms, but even castings bulk large. For instance, it was estimated that 2,500,000 lb. of 25-12 Cr-Ni tube supports alone are to be made in 1942. It was agreed that every plant and every process has its own problems to solve; some crudes are corrosive and some are not; temperatures and pressures range between extremes; consequently regulations of wide applicability would be almost impossible to set up. It was the consensus, however, that much alloy is now being used in supporting structures where actual metal temperature is less than 1400° F., and where a high strength cast iron like Meehanite would serve excellently. Finally it was agreed that a sizable percentage of the anticipated consumption of nickel and chromium in all wrought and cast forms could be saved by designing plants for a short life (say 3 to 5 years) rather than for a long life (say 20 years). Consequently it was unanimously recommended to the industry that no nickel and chromium be used *primarily to extend the life* of new plant beyond three years, if this can be done without increasing the expected "downtime" during that period by more than 2%, and that these same principles be used in the maintenance of existing equipment wherever it can be done without incurring delay.

Similar basic reasoning underlaid the deliberations of the furnace builders and the alloy foundrymen. The two meetings reached substantially the same conclusions by independent

routes. Since the conclusions will be applied *immediately* to new furnace designs, they are of great interest to users of heat treating and other industrial furnaces—who were not represented at the meeting, but who will have to work with the new equipment.

In general, the cast parts of furnace structures and handling mechanisms are to be appraised by (a) the stresses they have to carry, (b) the actual metal temperature and its fluctuation, and (c) the cost in time to replace. For example, if the part is difficult to replace but the temperature is low, use low alloy or none; if the temperature is high, use enough alloy to insure against production delays. If the part, like a work carrier, can be taken from a line and replaced without any delay, use low alloy even if it has a short life. Specifically, the preliminary recommendations as to maximum alloy type are as follows, wherein type 25-12 permits a maximum alloy content of 28% Cr, 14% Ni; 35-15 can contain up to 37% Ni, 17% Cr; and 65-15 can have 68% Ni, 19% Cr.

Type Alloy (Maximum) for Furnace Parts

I. For Furnace Parts Other Than Containers and Heating Elements (oxidizing or reducing atmosphere, and which are not subject to steep temperature gradients, fluctuations or quenchings).

METAL TEMPERATURE RANGE	FOR INTEGRAL PARTS	FOR NON-INTEGRAL PARTS
Up to 850° F.	Non-alloy	Non-alloy
850 to 1200° F.	Ni + Cr < 6%	Non-alloy
1200 to 1400° F.	Cr 25%, Ni 12%	Ni + Cr < 6%
1400 to 1900° F.	Cr 25%, Ni 12%	Cr 25%, Ni 12%
Over 1900° F.	Ni 35%, Cr 15%	Ni 35%, Cr 15%

II. For Parts Subject to Carburizing, Nitriding, "Dry Cyaniding"

Ni 35%, Cr 15%

Exception: Rotary retorts, 65 Ni, 15 Cr

III. For Severe Chemical Corrosive Attack

Ni 65%, Cr 15%

IV. Pots for Molten Baths

Up to 1400° F.; Non-alloy

Above 1400° F.; Ni 35%, Cr 15%

V. Heating Elements

Electrical elements operating up to 1200°

F.; Ni 65%, Cr 15%

Above 1200° F.; Ni 80%, Cr 20%

Fuel fired radiant tubes; Cr 25%, Ni 12%

VI. Quenching Fixtures and Hearth Plates

Above 1200° F.; Ni 35%, Cr 15%

VII. For Mechanical Stress, Above 850° F.

Concentrated stress; Ni 35%, Cr 15%

Less critical parts; Cr 25%, Ni 12%

Editorial Comment

These recommendations, which will guide the minimum requirements of the War Production Board, are apparently based on the feeling that the emergency will be of relatively short duration, short because the war may be short, or because alloy needs for the huge construction programs are greater than the subsequent maintenance needs, or that much more chromium and nickel can be secured from American mines, or that scrap returns will largely bolster our new supplies. The first is a hope rather than a probability, the second may not come to pass if de-graded castings are put into places where they cannot stand the use and abuse and require too frequent replacement, the third may be a certainty as to nickel in 1943 but not for chromium. We can depend on the fourth. However, even at best there is no alloy to waste and it may be anticipated that W.P.B. will ban the important alloy types known as NC-2 or HW and NC-1 or HX except where it can be proved that nothing else will serve.

Correct usage of available alloys, let it be repeated again and again, is not to be insured by governmental regulations *but by the careful engineering of each installation*. One gathers that this has not yet been done on the retorts for the Pidgeon magnesium process. A process which is not much beyond large scale experimentation is being magnified thousands of times, and a retort that has worked experimentally has been proposed. Design of this retort, its setting, its heating medium, its mode of operation—none of these has yet been scrutinized by expert foundrymen, furnace builders, and alloy steel metallurgists. Maybe 35-15 is more alloy than is needed (the magnesium on the inside doesn't attack plain steel). Wouldn't a clad or lined tube save much of the alloy? As a matter of fact, the Electro Metallurgical Co.'s ferrosilicon process, which has been operating experimentally for months, uses no alloy at all for the retorts.

Petroleum, chemical, metallurgical and furnace engineers can and will gladly save much valuable chromium and nickel by refining their designs and making the alloy work at its maximum. They know how to do it; they know the limitations of their metals and the needs of their processes. However, they don't want their savings wasted in *extravagant* expenditures in another construction, no matter how vital the new product may be to the national effort. ☛

Chrome Ore, Its Conservation and Substitution

By Advisory Committee to W.P.B.
on Metals and Minerals,
Ferrous Minerals and Ferro-Alloys Group
Gilbert E. Seil, Chairman

CHROME ORE is essential to industry as now conducted. Before being consumed, it is converted into three major groups of products: Ferro-alloys, refractories, and chemicals. By far the greater portion of the requirement is for ferro-alloys; it varies with the rate of operation of the steel industry and the proportion of steel going into machinery, tools, and war equipment. The next largest usage for the ore is in the manufacture of special refractories, and this also depends on the rate of operation of the steel industry. Chromium chemicals are used for manufacturing dyes, for tanning leather, for chromium plating, and in many miscellaneous fields.

The sources of chrome ore for metallurgical purposes are

Brazil	Greece	India	Russia
Philippines (high grade)			Sierra Leone
Rhodesia	Turkey		Serbia

Chrome ore for refractory purposes comes from

Cuba	Philippines	Rhodesia
Greece		Sierra Leone

For chemicals, suitable ore is mined in

Canada	Greece	Russia
New Caledonia	Serbia	Sierra Leone
Philippines (high grade)		Turkey
Rhodesia		Transvaal

Stocks of Chromite as of September 19, 1941

—The total stocks in the country, including Government's plus industry's, have increased about 40,000 tons in the last 12 months. During the same period, consumption has increased about 250,000 tons. For the last several months, consumption has been approximately equal to

supply. A significant point, which possibly will not be indicated till the end of 1941, is that during the next 60 to 65 days we expect to clean up all surplus stocks in the world, except for Masinloc refractory chrome, and thereafter we shall be on a current production basis. Except for increased production in the United States and Alaska, we cannot expect to increase our foreign supply appreciably, regardless of the shipping situation.

Contracts and deliveries of chrome ore to the Metals Reserve Co., as of August 19, 1941, by states and countries of origin, in long tons, were

	CONTRACTS	DELIVERIES
United States (California)	108,000	
Other countries		
New Caledonia	10,000	
Philippine Islands	166,000	8,000
Union of South Africa	160,000	35,260
Total chrome ore	444,000	43,260

The stocks of chromite at the end of August, 1941, in the hands of consumers and brokers amounted to 604,748 long tons, plus 5,620 long tons on hand by domestic producers, a total of 610,368 long tons.

Ferrochromium

The table on page 504 shows our production of ferrochromium for various years, together with the tonnage of ores required. Statistics for ferrochromium include all grades containing 70% chromium. The last column is the equivalent consumption of metallurgical ore, also in gross tons, containing 48% Cr_2O_3 .

The distribution of metallurgical ore, in 1940, by fields of use in the United States, was:

	GROSS TONS ORE
For low carbon ferrochromium (<2% C)	
For steels containing more than 4% Cr	105,000
For other purposes	7,000
For high carbon ferrochromium (>4% C)	
For machinery steels, tools, armor, etc.	73,000
For alloy exported to Great Britain —	
High and low carbon	15,000
For direct reduction in the manufacture of stainless steels	20,000
Total	220,000

Low Carbon Ferrochromium—It will be noted from the above table that a large part of the low carbon ferrochromium is used in the stainless steel field—that is, for steels containing over 4% chromium. This alloy must contain a very low carbon content in order to produce steels of a satisfactory grade. Low carbon ferrochromium is used for other purposes, but it will be noted that the total tonnage is relatively small.

Because the consumption of chrome ore that ultimately finds its way into stainless steel is so preponderant, the following tabulation was prepared to show the equivalent amount of ore used through the medium of stainless steels in various fields of applications:

Ore Consumption in U. S. in 1940 for Stainless

USE	PER CENT	ORE GROSS TONS
Automotive	37.8	47,000
Food handling	11.4	14,000
Transportation	11.3	14,000
Chemical equipment	6.3	8,000
Machinery	5.7	7,000
Household	3.5	4,000
Building construction	1.6	2,000
Oil industry (4 to 9% Cr)	8.0	10,000
All other	14.4	19,000
Total	100.0	125,000

High Carbon Ferrochromium—High carbon ferrochromium is used for the manufacture of steels for the automotive, machinery and tool-steel fields, and is the grade used for the production of armor plate and most other steels which find their way into the war program.

Manufacture and Consumption—Granted the knowledge of manufacturing technique which exists among the present producers, the only requirements for the production of ferrochromium are a sufficient electric furnace capacity for conversion of the ore to alloys and an adequate supply of suitable ore. Ferrochromium was produced in the last quarter of 1940 at nearly 2½ times the 1939 rate, which rate in itself was the highest on record, but the

rate of consumption of the alloy was still higher. This increased consumption was accomplished only by drawing on accumulated stocks, since the installed capacity for manufacturing ferrochromium at the start of 1940 was not sufficient to produce the alloy at the rate at which it was consumed during the last quarter. However, additional capacity was installed during 1940, so that at the start of 1941 the ability to produce the alloy had been increased to approximately 150,000 tons annually. Manufacturing capacity now under construction will add about 40,000

Ferrochromium Production in the United States (in long tons)

YEAR	70% FERRO- CHROMIUM	48% ORE EQUIVALENT
1929	35,000	88,000
1936	40,000	100,000
1937	45,000	112,000
1938	20,000	50,000
1939	50,000	125,000
1940	80,000	200,000
1940 last quarter, at rate of	120,000	300,000
1941 (estimate)	160,000	400,000

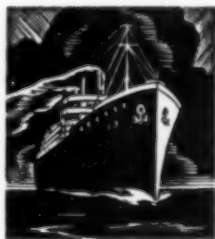
tons of alloy, some of which will increase production during 1941, and all of which will be in operation on or about Jan. 1, 1942. At that time the industry will be in a position to produce 190,000 tons of alloy per year.

During 1939 the total consumption of all ferrochromium in the United States, which of course was for civilian use, amounted to 50,000 long tons. In 1940 consumption was running at about the same figure until the latter part of the year when there was a very heavy upsurge of business. Increased use of chromium for civilian purposes, due to its substitution for nickel, the construction of chemical plants, tooling up of new industry, and expanding airplane construction, is estimated to have doubled this consumption, so that it now is running at the rate of 100,000 tons a year. It has been estimated that ordnance consumption of ferrochromium during 1941 will be 30,000 to 40,000 tons, and in 1942 it may reach 60,000 to 80,000 tons. Thus the production and consumption of ferrochromium are about balanced for 1941, and the increased producing capacity will just about take care of the anticipated increased consumption in 1942. In any event, if the ordnance demand for chromium increases more than anticipated, as could possibly happen through additional use of stainless steel in airplanes, the chromium needed for this purpose should be

taken from civilian uses. In view of the heavy requirements for imported chrome ore to sustain the present production, and the limited capacity for producing chrome ore in the United States, it would seem unwise to contemplate any further increase in the industry.

Metallurgical Ores

It has been customary to class chrome ores into three grades: (a) Metallurgical, (b) refractory and (c) chemical. Metallurgical ore is of the highest grade both with respect to its chromic oxide content and its high ratio of chromium to iron. To be classed as "metallurgical", the ore must contain about 48% Cr_2O_3 and have a chromium-to-iron ratio of at least 3:1. A division of this kind is largely arbitrary, and does not imply that ferrochromium cannot be manufactured from ores now classed as "refractory" or "chemical".



Leaving out all question of ore beneficiation, the effect of a lower chromium-to-iron ratio than the standard 3:1 is simply to produce a ferrochromium of lower chromium content and to increase the cost of manufacture per pound of chromium content. Whereas the 3:1 ratio will produce an alloy of about 70% chromium content, a ratio of $2\frac{1}{2}$:1 will lower the chromium in the alloy to about 65%, and 2:1 will lower it to about 60%. Since it will cost about the same per pound to produce the 60% chromium alloy as it will to produce a pound of alloy containing 70% chromium, the cost of production in the case of the lower grade will be increased about one-sixth.

In a like way, ores of less than the standard 48% chromic oxide content can be converted into ferrochromium but at an increased cost. Limiting the discussion to ores containing 35% or more of Cr_2O_3 (a figure which can be reached in most instances by concentration), the cost of smelting will be roughly inversely proportional to the chromic oxide content—that is, it will cost 20% more to convert 40% chromic oxide content ore to alloy than the standard 48% ore. It must be borne in mind, however, that the chromium throughput of the ferro-alloy plant will be reduced proportionately when either lower chromium-to-iron

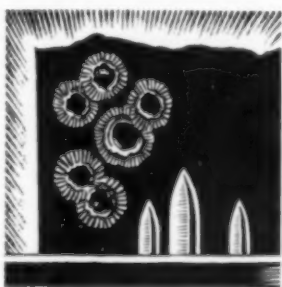
ratio or lower grade ores are smelted. Still, under emergency conditions practically any chrome ore can be considered as available for conversion.

In a war-time economy the chief question is economy in the use of strategic materials. The practice of using chrome ore direct in the steel furnace to add chromium to the steel is not followed except in the single instance of the Rustless Iron Corp., manufacturers of stainless steels. From the little that has been published on the process, it is believed that its economies depend on the availability of cheap stainless scrap. The over-all recovery of chromium is not as high as in the ferrochromium process and the operation uses a substantial amount of ferrosilicon.

Another recently developed method of adding chromium to steel is the use of exothermic briquettes. These are offered in two varieties, high and low carbon. The high carbon variety is a briquetted mixture containing, among other things, ferrochromium and sodium nitrate. The low carbon variety is a similar mixture without carbon, but containing calcium chromate.

Refractory Ores

In the refractory field the chemical composition has very little to do with the quality of the ore, since refractory usage requires chemical inactivity while the metallurgical and chemical usages require chemical activity. Present



practice in the refractory field is predicated on the use of ores too low in chromium to make them desirable or economical for metallurgical or chemical use. The grain size of the chromite in the ore is important in the refractory field but not in the other two fields. Ability to grind to a definite mesh ratio, a definite

particle shape, and a definite surface condition are essential to refractory ores. These properties cannot be determined easily in the laboratory. As a matter of fact, to determine whether or not an ore is suitable for refractory purposes, refractory products must be prepared and their quality determined in actual tests in the field in which they are used.

Since chrome ore is used in several types of refractory products, such as brick, cements, maintenance grade ore, ground ore, and plastic

mixes, no one grade of chrome ore is applicable to all.

At the present time there is approximately 6 lb. of chrome ore used as refractory in the production of each ton of steel, therefore an 83,000,000-ton year of steel production will require 250,000 tons of refractory chrome ore. However, the use of chromium refractories is increasing, and as the furnaces are pushed for increased production the use of chromium refractories will be appreciably higher than 6 lb. per ton of steel; therefore, the U. S. requirements for refractory chrome ore are expanding.

Chromium Chemicals

Specifications for chemical chrome ore vary, and choice is usually governed by cost per "unit of Cr_2O_3 " [one unit is 20 lb., or 1% of one ton] delivered to the chemical plant. Ores as low as 42% are usable. Relatively large stocks are in the hands of producers, and their present position is not unsatisfactory. If imports are cut off, supplies should be made available from domestic deposits as early as practicable.

Chemicals made are principally the chromates and bichromates of sodium and potassium. Needed amounts of chemical ore were:

1939	72,939 long tons 44% ore
1940	94,820
1941	113,786

While chromium chemicals, owing to their many uses for tanning, pigments, and textiles, are significant in industry's contribution to the war program, they are not used directly or substantially in the manufacture of armaments, as are the metallic products of chromium, such as ferrochromium. While the domestic demand

for chemicals has increased considerably since the outbreak of war, the increase is due to the general high levels of industrial operation.

Summary

From the foregoing it is evident that the following quantities of ore will be required to support the industry at the rate at which it will be producing in 1942:

For metallurgical purposes	475,000 gross tons
For refractory purposes	250,000
For chemical purposes	115,000
	<hr/>
	840,000

There is considerable increased activity in the extraction of low grade domestic chrome ores. It would be too optimistic to anticipate that domestic production could be increased beyond about 200,000 tons per year. Imported ores have been arriving to date (October 27, 1941) at about the rate at which they are being consumed, and the stocks are reasonably large. It is quite evident, however, that should the importation of ore be curtailed, the stocks together with the ore that can be produced in this hemisphere would not last us for more than about a year. It seems imperative, therefore, to maintain the flow of ore into the United States from foreign sources.

The grade of a metallurgical ore or of a chemical ore is determined by the chemical analysis, while the grade of a refractory ore is determined by its size and refractoriness. The chemical analysis does not enter into the grading of refractory ores, and therefore chemical grades and metallurgical grades cannot be used as substitutes for refractory grade ores. ☉

Chromium Recovery in Basic Openhearth

ABOUT a year ago the German publication *Stahl und Eisen* printed two papers and lengthy discussion on the proper steel making technique for the maximum recovery of chromium charged as alloy scrap, and the recovery of chromium added as ferro shortly before tapping. Since American steel makers should be interested in the conclusions for exactly the same reason which prompted the Germans to study the problem—namely, a shortage of the critical metal chromium—a rather full abstract is now presented of the

data for steels containing up to 1% chromium made in the basic openhearth furnace.

GEORG ROCKROHR said that several years ago, shortly after the study was initiated at Oberbilk Works, it became apparent that a fairly accurate but very rapid analytical method for chromium was necessary, in order that the experimenters would know the conditions in slag and metal as the heat progressed. This was achieved by a close study of an old volumetric method of titrating with KMnO_4 . By finding the minimum time for the various reactions, the exact amount of reagents and the best apparatus, the time, spoon

sample to report, was cut to about 15 min. A pronounced economic advantage that has resulted is that heats may be consistently produced on the low side of the specified range of chemistry.

Any plant that makes much alloy steel will have chromium in all melts, due to chromium in plant scrap, chromium in bought alloy steel scrap, and chromium picked up from furnace lining. The economic recovery of this chromium is quite as essential as the recovery from ferro.

The behavior of chromium in the charge is similar to manganese during the heat; the amount of chromium in the bath increases, decreases or remains constant in the same way as manganese, depending on whether conditions are reducing, oxidizing or in equilibrium. Decrease and increase of the chromium and manganese contents of the metal nearly always set in at the same moment. Figure 1 on page 508 shows relationships for a heat reduced from the start—that is, one in which both manganese and chromium continue to increase in the metal (and to decrease correspondingly in the slag) from the first sample to the last. Figure 2 shows the usual course of melting in which, because of oreing, manganese and chromium in the bath decrease at first but then rise when reduction begins. Figure 3 shows an unusual case in which chromium does not increase although the melt is reducing satisfactorily, as indicated by increasing manganese; this is because there is relatively little chromium in the system

and most of it is already in the bath. Figure 4 illustrates the opposite case in which the charge contained much chromium and little manganese; manganese in the metal then remains almost constant while chromium increases as it is reduced from the slag.

In these examples, the final residual chromium is from about 0.3 to 0.4% except under the conditions shown in Fig. 3, where there is little chromium in the charge. The recovery of alloy from the charge is greater, the more extensive the reduction, and may amount to 85% of the chromium; it becomes smaller in percentage with increased amounts of chromium in the charge (the same as for manganese).

The influence of the lime-silica ratio was derived by A. Ristow from the study of a large number of heat logs as follows: "(a) The average lime-silica ratio during the time when chromium is being reduced (transferring from slag to metal bath) was 1.59 to 2.3 for slags containing 7.5 to 9.6% of iron; and (b) the average lime-silica ratio was 2.48 to 2.77 in heats wherein the chromium content was decreasing after having reached a maximum, and the iron content of these slags was between 10 and 11% in these cases."

[In the discussion it was pointed out that the low lime-silica ratios could not be used in practice, "because such acid slags must be avoided for quality reasons". It might also be remarked that the practice of reducing manganese or chromium from the slag is unusual in American basic open-hearth practice, because the conditions which seem to be necessary for any substantial reduction are apt to lead to a high phosphorus steel. It is possible that some of the German plants making alloy steels may be using Swedish iron or iron made from Swedish ore together with selected alloy scrap so that the phosphorus on the charge is very low. In electric furnace practice we do, of course, recover chromium from the scrap and also obtain practically complete recovery of chromium from the added ferrochromium.]

The influence of temperature and the rate of decarburization was also commented on. Thus, A. MUND of Düsseldorf said that if the temperature during the boil is raised as high as the furnace refractories will stand, then the chemical conditions approach equilibrium and the chromium and manganese contents reach a steady maximum. It is therefore possible to attain 0.4% of residual chromium consistently in the steel when using charges with 0.6 to 0.7% chromium. High rates of decarburization result in better recovery of chromium, probably because a high rate of decarburization improves the reduction, and because heats which are reduced satisfactorily have a high

"Rhythm" (Opening the Tap Hole) as Photographed by Eugene Hutchinson for Colorado Fuel & Iron Products Co.



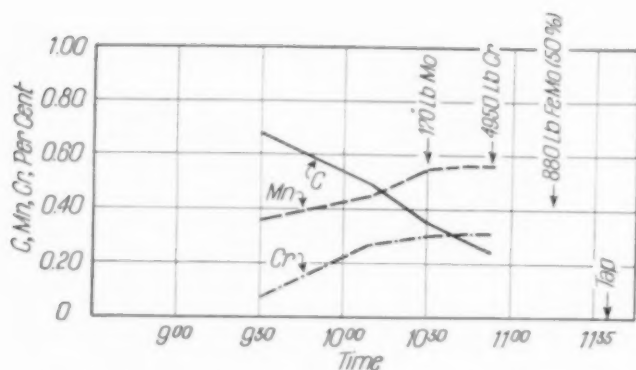


Fig. 1—Variations of Chromium, Manganese and Carbon in a Heat That Is Reducing Since the Start

recovery of the ferrochromium that is added later.

However, if the charge is too rich — especially in high chromium scrap — the heat is apt to melt soft. If this happens proper reduction, even with immediate carburization, is rarely attained. The carbon content of the charge should be at least 0.5 to 0.6% above that of the finished product.

Returning to the investigations described by ROCKROHR, only a few heats reasonably free from chromium were studied. When such heats are made, however, the recovery of chromium from the ferrochromium is lower than when the charge contains residual chromium — at least in the range of steels studied, containing 0.5 to 3% chromium and 0.1 to 0.55% carbon. Conditions prevailing at the beginning of this investigation showed an oxidation loss of 30% in casehardening steels melted to 0.13% carbon, decreasing to 17% in heat treatable steels with 0.55% carbon. This does not include steels containing about 3% chromium which show higher losses.

Turning now to the nature of the slag, MAX HAUCK of Westphalia described a research during 1936-39 on 20-ton basic openhearth furnaces making chromium and chromium-nickel steels of 0.40% max. carbon. Chromium was added as lump ferro containing 2% carbon. The quantities of slag were kept as constant as possible at about 12% by weight of the steel produced. Recovery of chromium was calculated from the preliminary analysis just before adding the ferro and from the ladle analysis; thus the chromium reduced from the slag between the start of the boil and the addition of ferrochromium was allowed for.

Recoveries were best in the heat treatable chromium-nickel steels with 0.20 to 0.40% carbon, next in casehardening chromium-nickel steels with 0.10 to 0.17% carbon, and least in casehardening chromium steels with 0.10 to 0.15% carbon.

High basicity of the slag results in high oxidation loss of chromium. This is reduced with decreasing CaO/SiO₂ ratio until the value of 3.0 is reached, beyond which no influence was found. In this respect the slag conditions check with those

noted above for reduction of chromium during the refining stage. Attempts to correlate chromium losses to FeO in the slag gave ambiguous results. If there is considerable chromium in the slag, derived from alloy in the charge, the recovery from ferro is also improved; 1% Cr in the slag increases recovery from the ferro by about 10%.

The effect of time in the furnace after the addition of ferro was also studied. It was noted that the losses are considerably greater during the first 10 min. than in the next 10 min. This indicates that the slag quickly becomes enriched in chromium, after which the loss of alloy from the steel per unit of time becomes smaller. Hot heats dissolve ferrochromium more rapidly, so that the time interval before tapping can be shortened. It

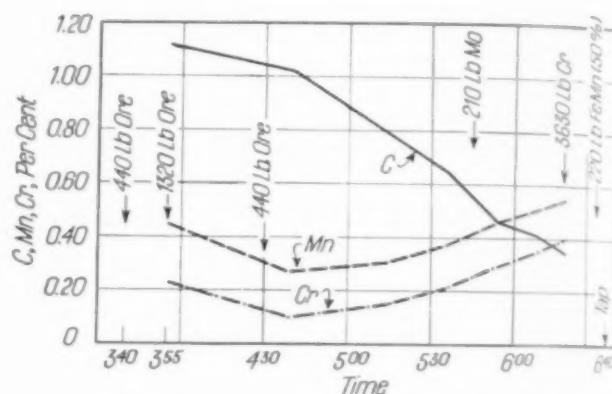


Fig. 2—Usual Course of Melting, Wherein the Bath First Loses Cr and Mn and Then the Slag Loses Them

is also thought that preheating the ferro may increase the rate of solution and thus reduce the time in the furnace, thus effecting a further economy of perhaps 10% — although this was doubted by others.

In this connection, ROCKROHR said he held the opinion for some time that the size of the lumps of ferrochromium had an effect on the oxidation loss, since unusually high losses followed the use of lots containing very small lumps. More careful observation failed to justify this opinion.

Returning again to HAUCK's studies, he found that deoxidation of the bath with spiegel before ferrochromium was added gave a very good recovery of chromium because of the combined salutary effects of carbon and manganese. Additions of ferromanganese were small since manganese is kept a little below 0.5% in casehardening steels and a little above 0.5% in heat treatable steels. Preliminary deoxidation of one heat with ferro-silicon also gave high recovery of chromium.

Actual figures for recovery from ferro were also given. For the majority of heat treatable steels chromium recovery was about 74% after 20 min. (the average time from addition to tap). When casehardening steels had the same FeO con-

Fig. 5 — Log of Typical Heat Showing Parallelism of Curves for Manganese and Chromium, and Their Relationship to Lime-Silica Ratio in the Slag

tent in the slag the recovery of chromium was only 42%. Chromium recovery was higher, however, in chromium-molybdenum steels than in chromium-nickel heat treatable steels, probably due to a well-deoxidized condition inherent in a relatively high content of manganese; in this case preliminary deoxidation with 10% ferrosilicon does not cause any further improvement.

Summarizing the studies on recoveries from ferro, HAUCK said that the chief factors are the degree of deoxidation before addition of ferrochromium, time from addition to tap, and the accumulation of chromium in the slag before the addition. Temperature cannot be used as a variable, because it is controlled by considerations of pit practice responsible for quality in the ingot.

ROCKROHN's investigations also extended to the final stage when additions are made. He noted that a large slag volume increased the losses of chromium. When this slag volume was more than normal (8% of the steel) due primarily to the use of sand-cast pig, part of the slag was skimmed off — an easy matter in a tilting furnace. The course of the reduction reactions is seldom interrupted by skimming some of the slag. This scheme proved successful, the oxidation loss of chromium was distinctly lowered and because of a more regular loss the

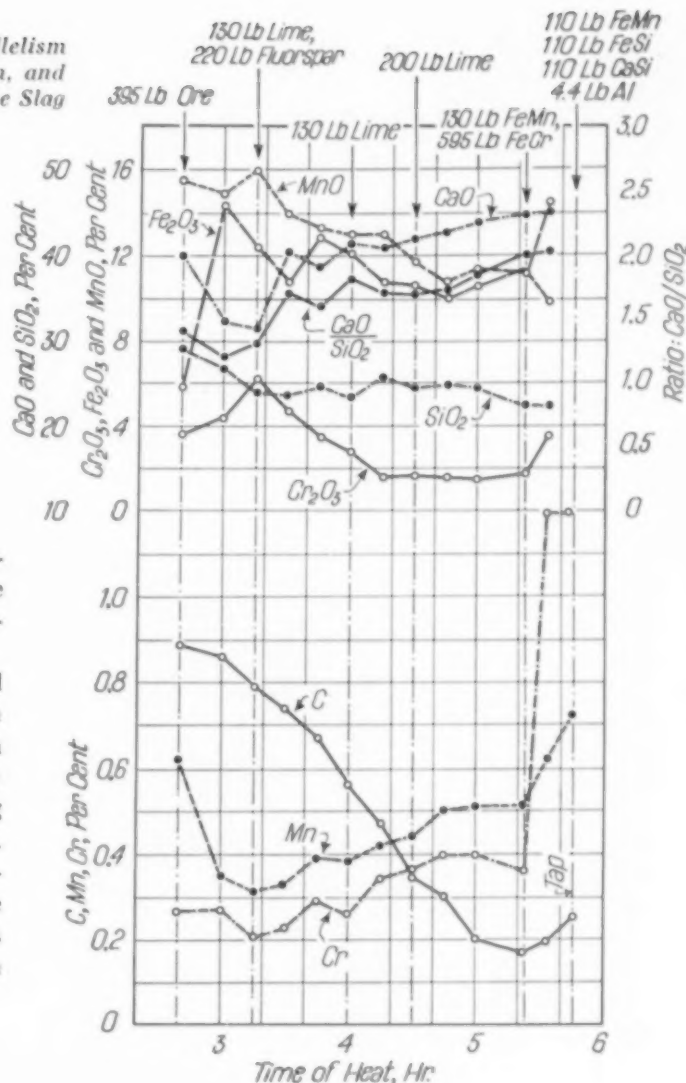
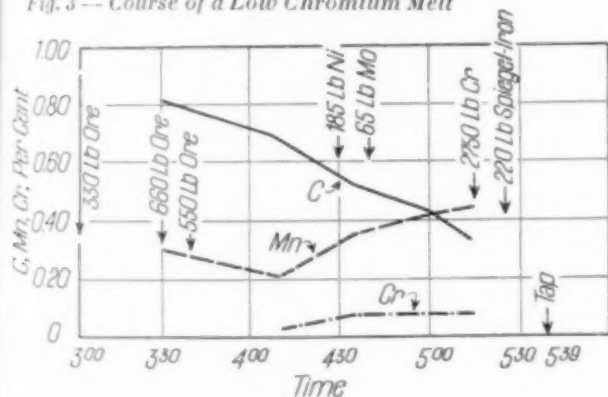


Fig. 3 — Course of a Low Chromium Melt



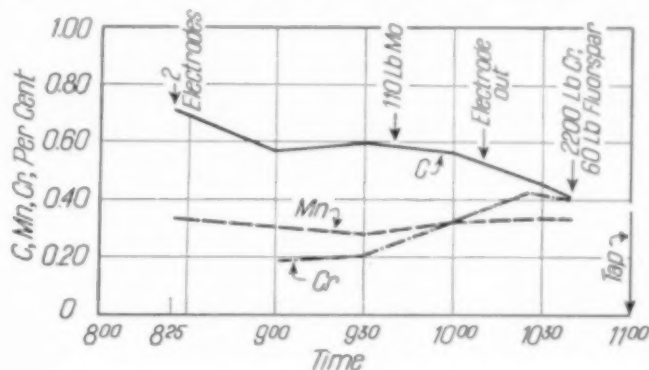
H. HARR of Bochum reported on operations in a plant producing several thousand tons monthly of "hard chromium steel" (ball bearing analysis?) using the pig-and-ore process. The slag is entirely free from chromium but the oxidation loss of ferrochromium is especially low because the amount of slag and its basicity are very low. Thus the recovery of chromium is regularly 85.5 to 86.5%.

Summarizing, the most favorable conditions are obtained when the (Continued on page 582)

exact adjustment of the final composition was further improved.

Losses in chromium at Oberbilk are now about 75% of those experienced before this investigation. In addition there is considerably greater uniformity in the chromium content as shown by ladle analyses. Examples cited indicate an expected recovery of 35% of the chromium in the charge (when it averages 1.0%) and a recovery of 70% when the average chromium content of the charge is 0.50%. In either case the residual chromium is 0.35% just before adding ferrochromium, and 85% of the latter reaches the ingot.

Fig. 4 — Course of a High Chromium, Low Manganese Heat

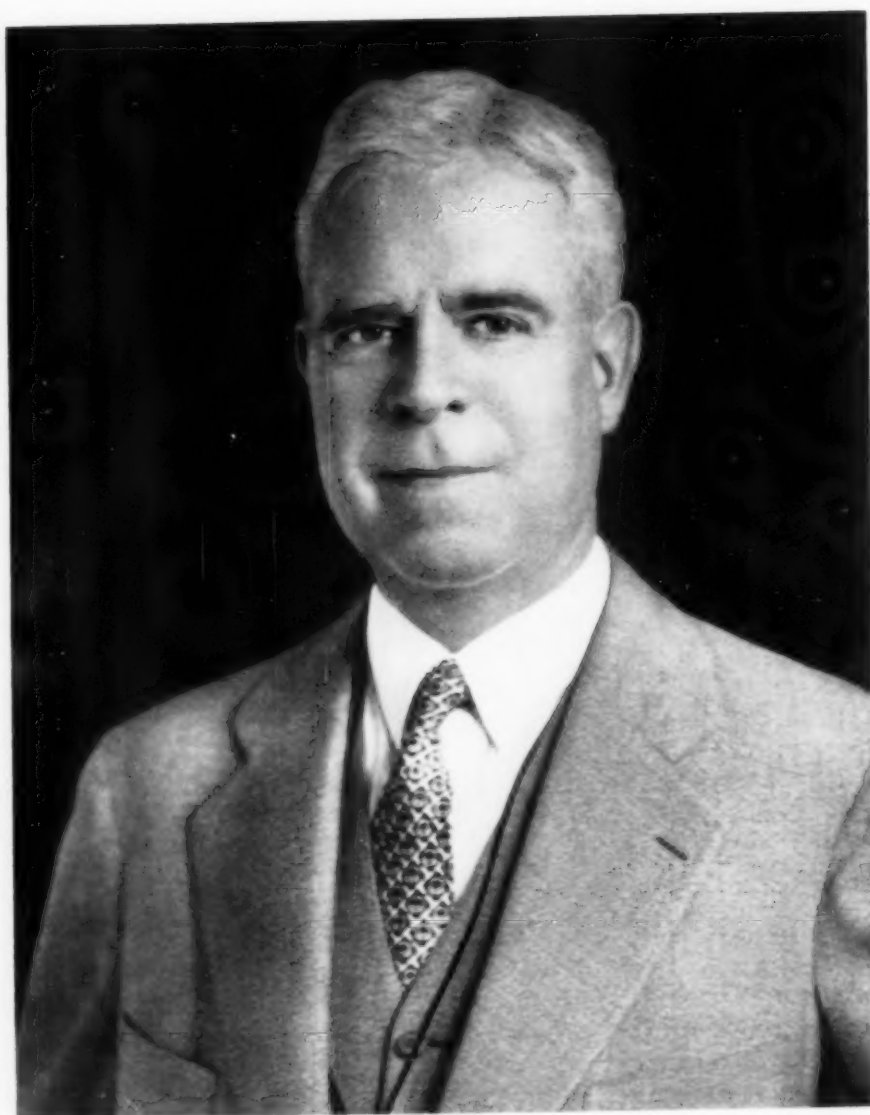


Albert Easton White

First President A.S.S.T.

Founder Member A.S.M.

Teacher and Mentor



A METALLURGIST who has achieved success and maintained a position of leadership over a long period of time is ALBERT EASTON WHITE. Although well known for his work as a teacher and consultant in the field of metallurgy, yet perhaps many of the thousands of new members of the American Society for Metals do not realize that he was among the first to exert an effort which finally resulted in the formation of the present society. Professor WHITE contributed a considerable — perhaps the necessary — share in bringing together two small societies which finally were welded into our present group.

An example of the difficulties which this situation imposed on him might be interesting. It so happened that the headquarters of the one group, the American Steel Treating Society, was in Chicago, while the other competing organization known as Steel Treating Research Society centered in Detroit. WHITE tried to get a representation from each group to meet with the other either at Chicago or Detroit, but the Detroit group refused to go to Chicago and the Chicago group refused to come to Detroit! Finally he suggested Battle Creek, about half way between the two cities, and both agreed. To ALBERT WHITE's credit is the evidence that once the two groups got together he kept them together. As a result of these efforts and because of his technical and scientific prominence he was chosen the first president of the amalgamated society, then known as the American Society for Steel Treating (1920). Somewhat later he again served his profession as president of the American Society for Testing Materials (1937).


Born at Plainville, Mass. on March 12, 1884, the son of a carriage builder and of American parents, Albert received his early education in nearby Providence, R. I. and his university training at Brown University (B.A., 1907) and one year of post graduate work at Harvard. He was

honored by Brown in 1925 with the honorary degree of Doctor of Science.

WHITE began his professional career at the Jones and Laughlin Steel Co. where he spent three years in charge of research before coming to the Chemical Engineering Department of the University of Michigan as an instructor in 1911. He has been continuously connected with the University since that time except for the period of the first world war. During these years he served his country in the Ordnance Department. He began as Captain and in a few months was promoted to Major and finally became Lt. Colonel, head of the Metallurgical Branch of the Technical Staff, Ordnance Department, U. S. A.

Upon his return to civilian life, Prof. WHITE organized a new department at Michigan known as the Department of Engineering Research and has been its director since. His idea was to make available to industry the large group of engineers and specialists who make up the engineering faculty at the University. Largely as a result of his efforts the present practical plan for carrying on research for industry at the University has been evolved. It is good for both industry and university, since it brings theory to the former and practice to the latter. Professor WHITE has given much time to teaching, as well, and a long line of metallurgical practitioners bear credit to his thorough grounding and inspiring example.

ALBERT E. WHITE has been a consultant to quite a range of industries. One of those with which he has been connected for more than a quarter of a century is the Detroit Edison Co. This has led him into the field of specialization for which he is perhaps best known, namely, the application of metals for power plants and for use at elevated temperatures. Results of his work in this field are known to engineers in the power plant industry and to metallurgists in various fields, since he has published something in excess of 35 articles in the technical literature.

In his leisure hours he may often be found on some golf course near Ann Arbor or in his "hideout" on the Huron River — a comfortable cottage without telephone connection. It is here that he keeps his treasured collection of Currier and Ives prints. But ALBERT WHITE is not at all the type that wants to be alone. Perhaps no one loves good company better than A. E., and few are as good company themselves. He has an intensely human manner and he radiates a genuineness of character instantly felt by those who meet him. 

Soft Steel for Plastic Molds

By H. C. Disston

Manager of Steel Sales

and J. K. Desmond *

Sales Metallurgist

Henry Disston & Sons, Inc.
Philadelphia

NCESSITY of conserving certain strategic elements for the national armament program is forcing toolsteel producers to review many of their alloy grades to determine in which cases the use of alloys gives a real rather than a fancied advantage. Such a re-examination of hobbing steels used by the plastic industry, which our laboratory has recently completed, has produced some interesting evidence that plain "iron" (in reality, a very soft steel properly produced and carefully heat treated) may be an entirely satisfactory material for many plastic molds where alloy iron has been used in the past. We shall compare the merits of the two different materials by appraising their ability to meet the following requirements: 1. Cleanliness. 2. "Hobability". 3. Hardenability. 4. Freedom from distortion. 5. Long life in service.

1. *Cleanliness.* By cleanliness is meant not only freedom from dirt and non-metallic inclusions, but also soundness — particularly towards the center of the bar. Porosity, splits, slag or other internal defects obviously spoil the highly polished finish necessary in plastic molds made of either low carbon iron or alloy steel. Both grades of hobbing material must be clean. By disk inspection we observe that iron, properly melted, is equal to the alloy in this quality.

2. *Hobability.* The fact that low carbon iron is superior in hobability or ductility is widely recognized. The table at top next page gives

the depths of cavities hobbled into fully annealed iron and low carbon nickel-chromium steel after three hobblings, using the same three pressures on each material.

The superior hobability of the iron as shown in this table may suggest that low carbon iron molds would therefore sink more readily under the compressive load of service than would alloy molds. The usual working pressure for most plastic molds is only from 1 to 2 tons per sq.in. (2000 to 4000 psi.) on the surface of the cavity. Iron and nickel-chromium test pieces, treated to simulate the core strength in finished molds, show that iron has an elastic limit of 44,000 psi. and the alloy 64,000 psi. The iron is stronger, then, by ten or twelve times than is needed to prevent permanent set under the mold cavity from the service loads usually employed. The low carbon iron should, in fact, have sufficient strength even for the occasional mold which works under pressures up to 15 tons per sq.in. Beyond this pressure molds cut from special steels not discussed in this paper are generally used. The difference between the inherent strength of the iron and of the alloy may be safely disregarded for this special service.

3. *Hardenability.* Both the hobbled iron and the hobbled alloy grades develop grain growth after heating strained material below its critical range. The large grain areas are structurally weak, and this condition can adversely affect the support beneath the cavity of the finished mold. This undesirable grain growth is more troublesome and less easily corrected in low carbon iron than in the low carbon alloy steel

*With acknowledgments to ERIC GRUNEMEYER, superintendent, Mack Molding Co., Wayne, N. J., for suggestions and production information.

Contrasting Types of Material for Plastic Molds

TYPE	ANALYSIS					DEPTH AT PRESSURES			TOTAL DEPTH	HOBABILITY
	C	Mn	Si	Ni	Cr	No. 1	No. 2	No. 3		
Soft steel	0.10	0.20	0.20435	1.025	1.774	3.234 in.	100%
Alloy	0.08	0.43	0.13	1.30	0.56	.352	.580	1.044	1.976 in.	61%

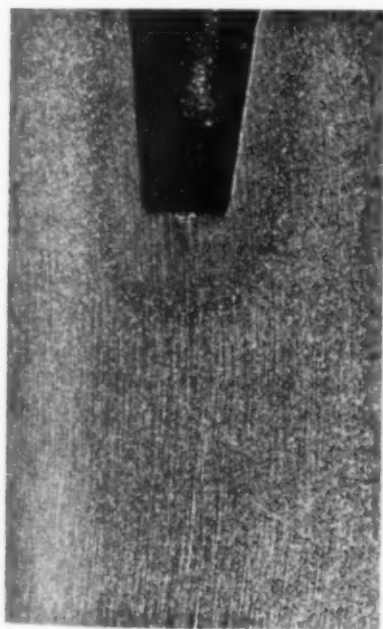
grade, but with proper heat treatment, as we shall show later in this article it can be completely eradicated.

The first photograph shows the large grains which grow in a zone around and under a cavity when a low carbon iron or alloy is heated to a temperature under its A_{c3} critical point. In the case of pure iron the A_{c3} point is very high, approaching 1670° F. In the various alloys the A_{c3} point is generally much lower, between 1525 and 1600° F., depending on the analysis in carbon and alloy. The second view shows hobbled material which has been improperly annealed (that is, heated under the A_{c3} critical point) by both the steel manufacturer and the mold manufacturer. The very large grains on the top and lower edge of the cut specimen were principally developed by long annealing in the steel mill of a surface-strained bar. Around and under the cavity large grains have developed in the area strained by hobbing.

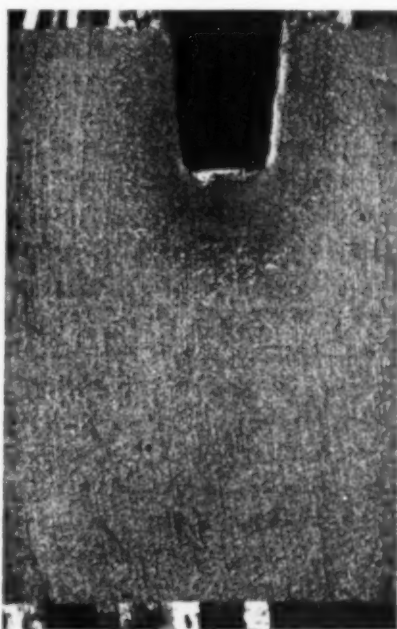
That the large grains can be eliminated by heating above the A_{c3} point is proved by the third photograph. In the case of the low carbon

iron, it requires 1700° F. to refine the structure. We suggest that this temperature or a higher one, possibly 1750° F., be used during the carburizing process; it will not only erase the weak grain area but also impart a deep case. With the alloy die steels, a lower temperature, which the die is likely to receive during some process of its preparation, will accomplish the same net result.

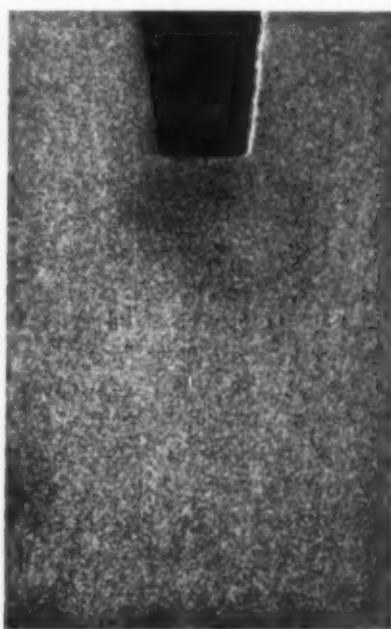
We believe it is the difference in temperature between the A_{c3} critical point of the alloy steel and of the low carbon iron which makes the former easier to heat treat satisfactorily. The low A_{c3} critical point of the alloy steels simplifies their carburization, and simultaneously eliminates the weak areas with large grains. In these steels a carburizing temperature of 1700° F., which is somewhat higher than generally used for plastic dies, should produce a case of 0.050 in. after a 5-hr. period at heat. An identical carburizing cycle on non-alloyed iron will produce a case of only 0.030 in. For the alloy steels a temperature of 1700° F. is from 100 to 150° above the A_{c3} point and the higher



Coarse grains in strained region after heating just under A_{c3}



Long anneal in steel mill grows columnar crystals in surface strained metal



Uniformly fine recrystallization by heating above A_{c3}

Conical Depression Hobbed in Die Blocks of Soft Steel Which Were Later Heat Treated

the carburizing temperature above the A_{c3} point of the steel, the easier it becomes to drive in a deep case.

For the iron, 1700° F. is only a few degrees above the A_{c3} point, and therefore barely high enough to carburize and to eliminate the large grain structure by recrystallization in the austenite. We recommend a carburizing temperature of 1750° F. for the pure iron to obtain a correct depth of case and suggest a direct quench from the carburizing heat into oil to preserve the carbon at the surface. The mold should subsequently, of course, be quenched in water from a grain refining temperature.

Carburizing depths of both steels will vary with their "normality". For example: The steel maker sometimes uses large quantities of aluminum to deoxidize heats of low carbon iron. If such metal is used for hobbing material, the carburizing results will naturally be inferior. If, therefore, the ordinary temperature used for carburizing is increased, iron may not only receive a satisfactory depth of case but the weak grain area will be assuredly corrected. The alloy steel is more easily carburized, but if the higher critical point of iron is recognized, casehardening will be entirely satisfactory.

After the formation of the case circumstances may favor the iron. When hardening it is the general practice to oil-quench the alloy die but, with large molds especially, water sometimes must be used to attain full hardness. The use of water on an alloy analysis may nullify the increased toughness to be expected from an alloy case. The iron die may be considered, as far as the surface goes, as a straight carbon, shallow hardening toolsteel designed to be hardened in water. Small or large dies can be properly and consistently quenched in water. Iron, then, skillfully handled by the heat treater, can be made the equal to the alloy in hardenability.


4. *Freedom From Distortion.* Much has been learned during the past few years about the excellent non-deforming characteristics of a shallow hardening carbon steel, even when compared with special non-deforming steels. Just now we do not have data, unfortunately, as to the comparative non-deforming properties of the low carbon iron and the alloy steels, but we would expect that carburized iron would at least equal the non-deforming properties of an oil quenched alloy, and be superior to a material whose surface analysis indicates an oil quench but is hardened by necessity in water.

5. *Life in Service.* The comparative per-

formance of a properly prepared iron die and an alloy die is likewise difficult to establish. Large, structurally weak grains would not be present under the cavity in a properly prepared mold of either iron or alloy. Dies made from any material must have sufficient core strength and a hard, durable case. It may be natural to assume that the alloy case will withstand abrasive wear better than the iron case. In practice it is found, however, that water quenching is usually more effective in producing uniform hardness. A water quenched mold may therefore withstand abrasion longer. Furthermore, it is necessary to clean and repolish plastic molds at intervals during their life; it is thought by mold makers that this operation removes more metal from the surface than is lost by wear. Plastic molds are generally subjected to a temperature of about 375° F., and this low temperature is no more destructive to the plain iron mold than to the alloy steel.

Most molds ultimately fail by cracking in the bottom of the cavity. The probable explanation for this failure is localized fatigue of the case. If it is remembered that the iron case and the alloy case, well supported, are each capable, theoretically, of withstanding several million service deflections, a comparison of the fatigue resistance of the two materials becomes academic, because engraving scratches or defects within the steel will encourage fatigue failure well below these figures. Production records of properly heat treated iron molds will run, however, consistently into many, many thousands and frequently several millions before failure occurs.

Another type of die failure sometimes develops on the top or "land" of the mold. There the working pressures are often concentrated on small areas and become much greater than the strength of either carbon or alloy steel. The effect of a concentrated pressure on a small area is of course to sink the surface at that spot. These forces, which affect production and may finally destroy molds, appear to us to destroy alloy and iron molds at about the same rate.

In conclusion we believe that the virtues of the alloy steels are derived mainly from their low A_{c3} critical points and that their use offers a convenience rather than a necessity. Low carbon iron, if respect is paid to its higher critical point, can equally meet the requirements of a hobbing material in cleanliness, "hobability", hardenability, freedom from distortion and long life in service. 

Standard Brass and Bronze Alloys of the Non-Ferrous Metal Institute

STANDARD INGOT ALLOY NUMBER DESIGNATION	CHEMICAL SPECIFICATIONS OF INGOT METAL					INCIDENTAL ELEMENTS (MAX.)					Notes
	COPPER	TIN	LEAD	ZINC	IRON	ALUMINUM (a)	NICKEL	MN	SB	S	
Leaded tin bronze											
2A 88-6-1½-4½	87.0-89.0	5.75-6.50	1.25-1.75	3.50-5.00	0.15 max.	None	0.75 max.	—	0.20	0.05	(a) "None" is defined as 0.005% when determined on 10-g. sample.
2B 87-10-1-3	86.5-88.5	9.25-10.5	0.75-1.25	1.25-2.50	0.15 max.	None	0.75 max.	—	0.25	0.05	(b) Copper plus tin plus lead must total 98.50%.
High lead tin bronze											
3A 80-10-10	78.0-81.0 (b)	9.25-10.5 (b)	9.0-11.0 (b)	0.75 max.	0.10 max.	None	0.50 max.	—	0.50	0.08	(c) Nominal (remainder).
3B 83-7-7-3	82.0-84.0	6.50-7.50	6.5-8.0	2.50-4.00	0.20 max.	None	0.50 max.	—	0.20	0.08	(d) Minimum tensile strength 60,000 psi.; minimum elongation in 2 in., 20%.
3C 85-5-9-1	83.0-85.0	4.50-5.50	8.5-10.0	0.50-1.50	0.15 max.	None	0.50 max.	—	0.25	0.08	(e) Minimum tensile strength 70,000 psi.; minimum elongation in 2 in., 30%.
3D 78-7-15	76.0-79.0 (b)	6.50-7.50 (b)	14.0-16.0 (b)	0.75 max.	0.10 max.	None	0.50 max.	—	0.75	0.08	(f) Minimum tensile strength 100,000 psi.; minimum elongation in 2 in., 10%.
3E 70-5-25	68.0-71.0 (b)	4.50-5.50 (b)	23.5-26.5 (b)	0.50 max.	0.10 max.	None	0.50 max.	—	0.75	0.08	(g) 0.10% min.
Leaded red brass											
4A 85-5-5-5	84.0-85.5	4.50-5.50	4.50-5.50	4.50-5.50	0.25 max.	None	0.50 max.	—	0.25	0.08	(h) 3.00% min.
4B 83-4-6-7	82.0-83.5	3.50-4.25	5.75-6.75	6.00-7.50	0.25 max.	None	0.50 max.	—	0.25	0.08	(i) Copper plus iron plus aluminum must total 99.50%.
Leaded semi-red brass											
5A 81-3-7-9	79.5-81.5	2.75-3.25	6.50-7.50	8.50-10.0	0.35 max.	None	0.50 max.	—	0.20	0.08	(j) Nominally 1.00% max. but total impurities including iron but excluding manganese must be 1.00 max.
5B 76-3-6-15	75.0-76.75	2.75-3.25	5.50-6.50	14.0-16.0	0.35 max.	None	0.50 max.	—	0.20	0.07	(k) U.S. Army and Air Corps use Federal Specifications Board (Federal Standard Stock Catalog) for ingots.
Leaded yellow brass											
6A 71-1-3-25	70.0-71.75	0.75-1.50	2.50-3.50	25.0 (c)	0.50 max.	None	0.50 max.	—	0.10	0.05	(l) Society of Automotive Engineers, Aeronautical Material Specifications.
6B 66-1-3-30	65.0-67.5	0.75-1.25	2.75-3.50	30.0 (c)	0.50 max.	None	0.50 max.	—	0.10	0.05	(m) When marked F.S.B. the service uses the Federal Specifications Board (Federal Standard Stock Catalog).
6C 60-1-1-38	58.0-61.0	0.75-1.25	0.75-1.25	37.85 (c)	0.50 max.	0.10-0.20	0.50 max.	—	0.10	0.05	(n) Lead is limited to 0.20% max.
Leaded high strength yellow brass (manganese bronze)											
7A 60,000-20 (d)	56.0-60.0	0.50-1.00	0.50-1.00	37.5 (c)	0.75-1.50	0.25-1.00	0.50 max.	0.50 (g)	0.05	0.05	(o) Copper 63% min.; tensile strength 115,000 psi. min.; elongation in 2 in., 12% min.
High strength yellow brass (manganese bronze)											
8A 70,000-30 (e)	56.0-59.0	0.50 max.	0.25 max.	39.25 (c)	0.75-1.50	0.75-1.50	0.50 max.	0.50 (g)	0.01	0.05	(p) FF-H-106 FF-H-111 FF-H-116a FF-H-121a FF-H-136 WW-P-541
8B 100,000-10 (f)	61.0-63.5	0.05 max.	0.10 max.	26.50 (c)	2.50-3.50	4.50-6.00	1.00 max.	4.50 (h)	0.01	0.03	
Aluminum bronze											
9A 87½-3½-9	86.5-88.0 (i)	0.10 max.	0.05 max.	0.10 max.	3.25-3.75 (i)	8.50-9.50 (i)	0.25 max.	0.25	0.01	0.05	
9B 89-1-10	88.25-89.5 (i)	0.10 max.	0.05 max.	0.10 max.	0.75-1.25 (i)	9.75-10.5 (i)	0.25 max.	0.25	0.01	0.05	
Leaded nickel brass (nickel silver)											
10A 57-2-9-20-12	55.0-58.0	1.50-2.50	8.00-10.0	20.0 (c)	1.00 max.	None	11.0-13.0	0.50	0.25	0.05	
10B 60-3-5-16-16	58.0-61.0	2.50-3.50	4.50-5.50	16.0 (c)	1.00 max.	None	15.5-17.0	0.50	0.25	0.05	
Leaded nickel bronze (nickel silver)											
11A 64-4-4-8-20	63.0-65.0	3.50-4.50	3.50-5.00	7.00-10.0	1.00 max.	None	19.5-21.0	1.00	0.25	0.05	
11B 66-5-1½-2-25	64.0-67.0	4.00-5.50	1.00-2.00	1.00-3.00	1.00 max.	None	24.0-26.0	1.00	0.25	0.05	

Index of Corresponding or Similar Specifications

SPECIFICATIONS FOR INGOTS			SPECIFICATIONS FOR CASTINGS FROM GIVEN INGOT		
NON-FERROUS INGOT METAL INSTITUTE	FEDERAL A.S.T.M. SPECIFICATIONS B30-40 T BOARD (k)	U.S. NAVY	FEDERAL SPECIFICATIONS BOARD AND U.S. ARMY	U.S. AIR CORPS	S.A.E., A.M.S. (l)
Leaded tin bronze					
2A	QQ-B-701 (No. 1)	F.S.B. (m)	QQ-B-691a (No. 1)	F.S.B. (m)	4845 A (n)
2B	QQ-B-701 (No. 6)	F.S.B.	QQ-B-691a (No. 6 and 6X)	F.S.B.	4842
3A	—	—	—	—	—
3B	—	—	—	—	—
3C	—	—	—	—	—
3D	QQ-B-701 (No. 7)	F.S.B.	QQ-B-691a (No. 7)	F.S.B.	4840
3E	—	—	—	—	—
Leaded red brass					
4A	QQ-B-701 (No. 2)	F.S.B.	QQ-B-691a (No. 2)	F.S.B. and 11306 Grade A	—
4B	—	—	—	—	—
Leaded semi-red brass					
5A	QQ-B-701 (No. 4)	F.S.B.	QQ-B-691a (No. 4)	F.S.B.	—
5B	—	—	—	—	—
Leaded yellow brass					
6A	—	—	—	—	—
6B	—	—	—	—	—
6C	—	—	—	—	—
Leaded high strength yellow brass (manganese bronze)					
7A	—	—	—	—	—
High strength yellow brass (manganese bronze)					
8A	QQ-B-731a	F.S.B. and 46 B16b	QQ-B-621 "A"	F.S.B.	4860
8B	—	—	QQ-B-726a	F.S.B.	4862 (o)
Aluminum bronze					
9A	—	46 B19 a	QQ-B-671 Grade A	F.S.B. and No. 11076	4871
9B	—	—	QQ-B-671 Grade B	F.S.B.	—
Leaded nickel brass (nickel silver)					
10A	—	—	—	—	—
10B	—	—	—	—	—
Leaded nickel bronze (nickel silver)					
11A	—	—	—	—	—
11B	—	—	—	—	—

Gathering, editing and distributing

INFORMATION for users of alloys

I—Field offices of the
Development and Research Division
C—Distributor's Casting Service Centers

NICKEL

To aid users of Nickel alloys, thirty service centers are maintained in industrial areas. From these strategically located key points, our field representatives are on call to advise American industry about the selection, fabrication and uses of ferrous and non-ferrous materials. Assistance is also given on problems arising

from the temporary lack of Nickel.

Through the years, research, field studies and user experience have all contributed to a fund of practical, time-proved information. Many of these data have been compiled in convenient printed form, useful both to experienced men handling new materials or performing un-

familiar operations... and to the many new employees.

Now... when minutes and materials are so vital... make full use of this metal-working experience. Send for a check list of helpful printed pieces on the selection, treatment, fabrication and use of Nickel alloys, or send your specific questions to:

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK, N. Y.

Electroplating Turns From Peace to War

By Joseph B. Kushner
Metal Finishing Consultant
New York City

THE electroplating industry seemingly suffered a mortal blow when the Office of Production Management, and subsequently the War Production Board, ruled that April 1, 1942 was to be the final deadline for all non-defense and non-essential civilian plating, even though the required metals were already in the shop. Automotive equipment of every sort, and even the so-called Victory models of bicycles were to be stripped inside and out of all "bright work", that being defined as plating using aluminum, cadmium, chromium, copper and nickel. The gloom was so thick in plating circles you could cut it with a bus bar and the long faced boys were ready for the wake.

Fortunately, the rumors of its sudden death have been, in MARK TWAIN'S words, greatly exaggerated. The industry is already convalescing and we venture to predict will be up and around, healthier than ever, in another six months, because electroplating has been drafted for the Victory program and its classification is I-A! A look at where electroplating and its associated art of electro-finishing are concerned with the war effort will prove this.

Aluminum is literally the skin and bones of our bombers and fighter planes. In many applications it must, however, be protected from corrosion. For this purpose anodizing is resorted to, a process in which electrolytic oxidation converts aluminum to the oxide at all surfaces exposed to the action. While it is an "anodic" operation, it involves electrolysis and makes use of the same type of equipment as electrodeposition; for this reason we take the liberty of classifying it as a plating process (which it

strictly is not, since in actuality only hydrogen and the metals can be electrodeposited).

Two methods for anodizing are in general use. One utilizes chromic acid as the electrolyte, the other uses sulphuric acid. In both, the aluminum is made anodic in the bath and a potential of 30 to 40 volts is put across the bath. Depending on the conditions set, a film of aluminum oxide in amorphous form is produced, ranging in thickness from 0.0000005 to 0.0008 in., tough, resistant to abrasion and a perfect base for paint. The aviation industry generally uses the chromic acid process, as described in specifications issued by the Army Air Corps. In some applications where the aluminum alloy carries 5% copper or more, the sulphuric acid process is the only one suited.

We might also mention that electroplating on aluminum is now successfully being done by a fairly recent patented method described by W. J. TRAVERS in the 1939 *Transactions* of the Electrochemical Society. To give an idea of the defense applications of such a process: Aluminum is highly desirable as an electrical conductor for certain uses. The problem of electrical contact (always difficult with aluminum) is overcome by silver plating the aluminum contact surfaces.

Brass plating finds wide use in our war effort. Many small parts formerly made of brass bar stock, such as nuts, screws, eyelets, and so forth, are now being made of brass plated steel because of the shortage of copper. A quite important defense use is in the bonding of rubber to metal. Rubber, it seems, sticks best to brass and for this purpose brass is plated on steel and other metals to which rubber is to be bonded. The brass deposit must have a certain, definite composition range for best results, as



Ultra-Modern Plating Room in Aircraft Engine Plant, for Copper, Cadmium and Tin Plating

demonstrated by H. P. COATS in the 1941 *Transactions* of the Electrochemical Society.

Cadmium is one of the more extensively used electrodeposits in our Victory program. It possesses excellent non-corrosive properties, particularly in humid atmospheres, and for this reason is plated on many airplane parts as well as on certain parts and fixtures of tanks, marine engines and battleships. Brass, as well as steel, is plated with cadmium for corrosion resistance. The protective action is both mechanical and electrochemical, inasmuch as cadmium corrodes sacrificially in the presence of more electro-positive metals.

Typical airplane parts that are cadmium plated are ignition wire harnesses, radio shielding and various small items prone to corrosion. The thickness of the deposit usually runs between 0.0001 and 0.0005 in. Solutions are of the standard cyanide type, usually including an organic brightener. A typical plating bath composition is:

Cadmium metal	3 to 4 oz. per gal.
Sodium cyanide	9 to 10 oz. per gal.
Caustic soda	$\frac{1}{2}$ to 1 oz. per gal.

Chromium — War industry is making more and more use of hard chromium plating. Tools, dies, parts, molds, shafts, engine cylinder bores and pistons are among the many parts that are being plated with chromium for increased hardness, low coefficient of friction, wear resistance and general building up. Interior surfaces of anti-flash muzzle guards on rapid fire guns are

also plated with chromium for oxidation resistance. Machine parts, dies and tools that formerly would have had to be discarded because slight undersize prevented them from meeting tolerances, can be built up to proper dimensions. Deposits of "hard" chromium are extremely hard, sometimes going as high as 950 Brinell. Such deposits increase the wear life many-fold of parts subject to constant usage. When plating hard chromium on steel a heat treatment after plating at 350 to 400° F. is necessary to drive off most of the absorbed hydrogen. Details of the process, the use of conforming anodes, and characteristics of the plate are given by ROBERT D. ZIMMERMAN in Chapter 8-B of "The Book of Stainless Steels".

Another use that takes advantage of chromium's hardness, decorative appearance and corrosion resistance, is in the plating of the surgical and dental instruments of the army and navy. Chromium-plated instruments stand up well under repeated steam sterilizations.

The deposit may vary from 0.00001 in., as is used on the medical instruments, to 0.01 in., as may be necessary to build up a worn shaft.

Copper — One of the widest uses for copper plating is as a stop-off for carburizing. Copper plate is practically impervious to carbonaceous gases, so steel surfaces thus coated remain relatively soft and tough after heat treatment whereas bare parts pick up carbon and can be heat treated to maximum hardness. There are a hundred and one applications for

this type of stopping-off operation, including the provision of drillable spots on face hardened armor plate, engine parts, dies and machine tools.

A typical use is in the production of a gear for airplane motors. The web of the gear must be tough and durable; the teeth, on the other hand, have to be extremely hard. To accomplish this the gear blank is given a copper deposit 0.0005 in. thick, the gear teeth are cut, exposing the wearing surfaces, which are then carburized and hardened. In Wright Aeronautical Corp. practice, described by U. A. MULLIN before the Society of Automotive Engineers in 1941, the steels to be carburized carry from 0.08 to 0.14% carbon. The steels and alloying metals are 2512 with 5% nickel; 3312 with 3.5% nickel and 1.5% chromium; 4612 with 1.75% nickel, and 0.25% molybdenum. Gas carburizing is used exclusively and the penetration varies from 0.025 in. in 2 hr. to 0.07 in. in 13 hr., at full heat (1700° F.). After the carburizing operation the work is annealed for 4 hr. at 1200° F. to permit the carbon to diffuse inward and reduce the carbon concentration at the very surface. It is then quenched from 1450 to 1500° F. in oil and drawn 4 hr. at 250° F. The carburizing material used is gas, evolved from one of the proprietary compounded di-pentenes.

Besides its use as a carburizing stop-off, copper plating is required for a great many vital electrical and magnetic equipments. A typical example of this application is in depositing copper on alnico magnets to provide a thin conducting skin.

Gold. In a report issued March 12 by the War Production Board, HARVEY A. ANDERSON, chief of the Conservation and Substitution Branch, placed cadmium and chromium in Group I of those materials most vitally needed for war purposes and not generally available for civilians; on the other hand gold (together with cements, sulphur, salt and silver) is in Group III, those materials available in some quantity for other than strictly war purposes. Gold may therefore be the one metal of which there is no shortage, bizarre as that statement may sound!

Gold finds several important uses in our Victory campaign. To build up *esprit de corps* we have enormous numbers of buttons, insignias, emblems and braid for Army, Navy,

aviation and marine uniforms, small items that are gold plated to specification. Formerly, the Army specification required the gold to be applied to buttons by fire gilding, a process in which a mercury-gold amalgam paste is smeared on the button and the button is then fired, leaving a smooth, closely adherent deposit of gold. However, because the process is dangerous to health and requires operators of considerable skill, the Army specifications have been changed to permit electroplating of buttons. A typical Army specification for officers' buttons calls for a minimum deposit of ½ grain of 24-carat gold on each 45-ligne button.

On the more utilitarian side, gold plated infra-red reflectors are now speeding up the drying and baking of painted and lacquered surfaces of many defense items. Another interesting application of gold plating is for protecting silver conductors that are to be used in sulphurous atmospheres. These silver conductors are used in radio transmission where the high frequency of the current causes what is known as the "skin effect" — that is, most of the current is carried in the outer layers of the conductor. In a sulphurous atmosphere silver is converted at the surface to the dark colored sulphide which is a relatively poor conductor and therefore offers higher resistance to the flow of the current. The silver tape is accordingly plated with gold — which is in itself an excellent conductor, and impervious to the cor-

Representative Group of Wright Aircraft Engine Parts, Copper Plated and Tin Plated Prior to Selective Heat Treatment, and Cadmium Plated for Corrosion Protection



rosive action of the sulphur atmosphere. In this particular application the gold is plated in an automatic continuous operation and the deposit is unusually heavy, about 1% by weight of the conductor.

Indium is a comparative newcomer in the plating field but it is already in considerable use for defense purposes. When alloyed with other metals it generally imparts to them increased non-corrosive properties. Civilian uses are not restricted, but its principal use is for plating the bearing surfaces of tank and airplane engines; possibly its real function is to resist the corrosive attacks of hot lubricating oils and decomposition products to be found in the engine crank case. The correct amount is rather critical—a very small quantity of indium diffused into the very surface of the bearing metal brings about considerable improvement in the wear life of the bearing.

Two types of indium baths are in use, the indium cyanide bath and the indium sulphate bath. In a typical procedure, the bearing is a thin walled, steel backed sleeve; the steel is accurately formed and machined and carries a layer of silver a few thousandths of an inch thick. On this is electroplated about 0.001 in. of lead and on this in turn is plated the indium to an amount not exceeding 4% by weight of the lead. Larger sized bearings are made the plating tank by corking one end or using a special fixture. With the cyanide solution carbon anodes are used, and with the sulphate solution pure indium anodes are used. After the proper weight of metal has been deposited, the bearing is heat treated to cause the indium and lead to diffuse into one another. At Wright Aeronautical Corp. plants an oil bath is used for this purpose, maintained at 340° F.; the heat treatment lasts for 2 hr.

Iron—A fair amount of iron is electro-deposited and electroformed in our war industry. Iron plating is used for building up worn shafts and tools, though in many such cases it has been displaced by chromium and nickel. Iron deposits may be subsequently carburized and casehardened. One application of iron plating that is of considerable interest is a patented process for electroforming iron into molds for rubber tires and plastics. Molds are

cut in one of many easily workable materials—even wood—their surfaces are made conductive by spraying or chemically depositing a layer of metal a few atoms thick, and then plating a thick layer of iron. This iron surface can then be backed up with matrix metal of some sort.

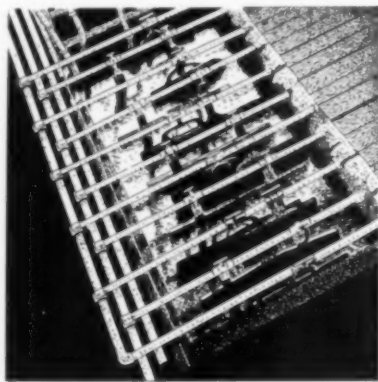
The electroforming method saves a great deal of time and permits a number of similar molds to be made with a minimum of labor.

(We must not forget, also, that electrodeposited iron plates are used at Uncle Sam's Bureau of Printing and Engraving for printing defense stamps and victory bonds. Good buys! —Adv.)

Lead plating also finds wide use in the war program, being used on small bushings for lubricating purposes. Lead is also plated on copper rods to act as a lubricant in wire drawing. Lead is plated on the inside of certain types of artillery shells, to resist the corrosive effects of the ingredients contained. When bushings are plated the inside surface is the one plated, and the part is made the "plating tank", as in indium plating, by a special corking gadget. The usual type of lead plating bath in use is the fluoborate solution, but the fluosilicate bath has been and can be used for larger installations. A layer of 0.0005 in. is about the average thickness plated for its lubrication properties.

Magnesium, like aluminum, cannot be plated out from aqueous electrolytes but is capable of being anodized by special electrolytic processes. Details are given in U. S. Navy Aeronautical Specification PT-13. Since we started our magnesium-from-sea-water recovery plants going, magnesium has begun to replace aluminum in a number of important applications, particularly on aircraft, where lightness and strength are of great importance. Anodizing permits the magnesium to take a coat of paint. Two or three other pickling processes are available for making an excellent base for protective paint. In all of them an extra fine job of degreasing is prerequisite. Recently Dow Chemical Co. has also announced the development of a method for plating metals on magnesium.

Nickel is plated as an undercoat before chromium in many war applications. It is also used to build up worn parts and shafts. Fire



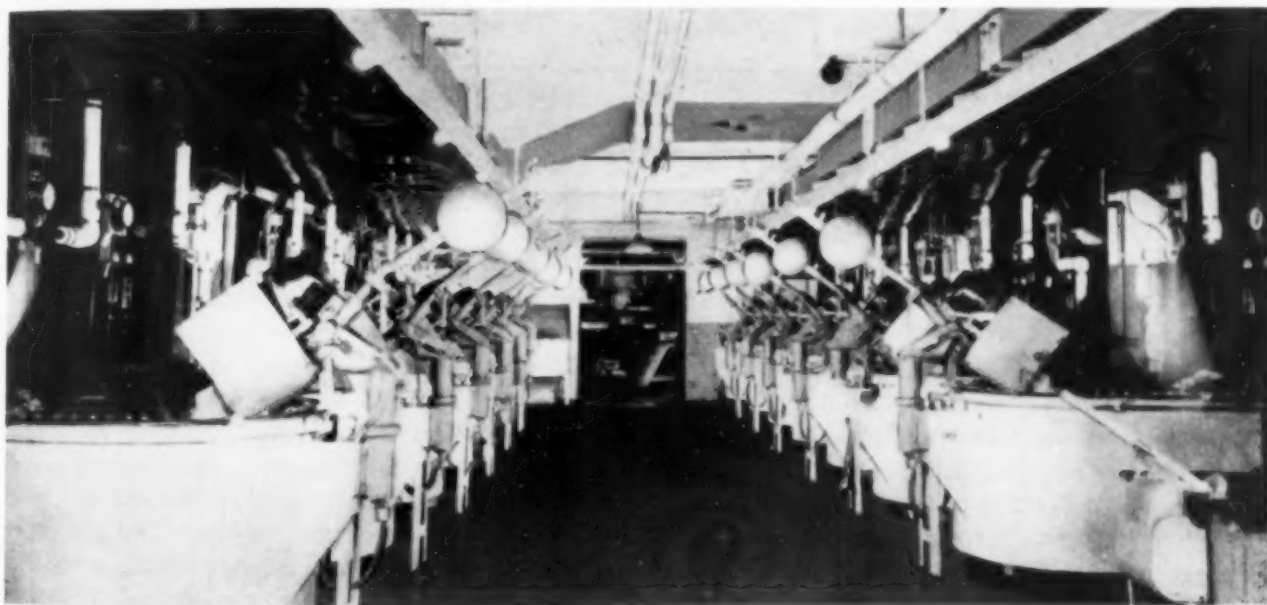
extinguishers use much nickel plate and, in general, it is found wherever good wear resistance and anti-corrosive properties are wanted. The extensive installations for bright nickel plating on articles of peacetime are now rapidly being converted to war uses.

Platinum Metals — Iridium and platinum are plated on electrical contact points that have to withstand continuous sparking. As the supply of tungsten metal becomes more and more restricted, they will doubtless be plated on spark plug points and magneto contacts, replacing tungsten for this use.

Rhodium is used wherever extreme resistance to corrosion is desired, particularly on delicate scientific instruments. One of its best war uses in electrodeposited form is as a first reflecting surface on air field and anti-aircraft searchlights. Its civilian use is, in fact, completely restricted. Rhodium is deposited on electroformed nickel and copper reflecting surfaces producing a highly reflective first surface

FAUST before the Electrochemical Society in 1938). Bearing shells are put through a regular cleaning cycle and are then plated in a regular silver cyanide bath of standard composition. Another use for silver plating in our war effort is on low voltage contact points and areas that do not have to take much sparking. With the situation critical as far as tin is concerned, silver electrodeposits may be able to replace lacquered tin as linings for certain types of containers. Future war uses may profit from work done by Studebaker Corp. when chromium plated hardware was eliminated. Bonderized steel was electroplated with silver, an indium flash added, and the two diffused into a tarnish resisting surface by baking at 350° F.

Westinghouse's Newark Works Has a Line of Barrels for Electroplating Permanent Magnets. As might be expected, this room has economical electrical equipment: A rectifier supplies direct current, and each barrel is cut off automatically as mined amount of energy, a measure of the deposit



mirror (overall reflective index about 75%) which is non-corrosive and capable of withstanding the high heat generated by the illuminating medium. The present author has described this in *Metals and Alloys*, May 1940.

Silver — Comparatively recent research, mentioned at intervals in *METAL PROGRESS*, has demonstrated that silver in electrodeposited form is an excellent bearing metal, particularly when plated out with lead. A typical bearing alloy of silver that can be plated out is one containing 4% lead (described by THOMAS and

Tin — Electrotinning has been done commercially in competition with hot dipping of tin plate for several years. Several new plants for manufacturing the stock from which tin cans are made have been announced by leading steel companies. It is estimated that some 17,000,000 "base boxes" of tinplate will be so produced in 1942, somewhere about one-quarter to one-third of our expected make, and this will do much to relieve our critical shortage of this metal. By electrodeposition it is possible to reduce the

(Continued on page 580)

Auto-Nitrification of Steel as It Scales

By G. H.ENZIAN and H. F. BEEGHLY

Research & Development Division
Jones & Laughlin Steel Corp.

and P. P. TARASOV

Cleveland Wire Works, General Electric Co.

IN an article in February entitled "Nails From Ruins of St. Pierre" the authors described the appearance of some relics of the volcanic disaster of 1902. Studies of the thick oxide coating indicated they had been exposed several hours to temperatures above 2000° F. while in contact with volcanic dust. Detailed examination of the metallic core of these burned nails revealed some interesting further information, as follows:

Chemical Analysis — Marked differences in ductility and the nature of fracture of certain nails led to the supposition that they might possibly differ in composition. Unfortunately, the quantity of steel remaining from a single nail was not sufficient to permit its complete analysis by conventional methods. A number of nails were combined, therefore, and the common elements determined on this composite sample. However, a micro method developed at the Jones & Laughlin Research and Development Laboratory permitted an accurate quantitative determination of nitrogen from samples as small as individual portions of a nail.

Preliminary chemical determinations on a very limited amount of material from one nail were made by DANIEL HARMON, chief chemist of Allegheny Ludlum Steel Corp. at Dunkirk, N. Y., and he reported 0.039% carbon and 0.038% nitrogen. Analysis of a composite sample by J. & L. laboratory gave 0.03% C, 0.34% Mn,

0.095% P, 0.116% S, and 0.02% Si. Nitrogen, by the micro-chemical method mentioned, varied widely in samples from different nails, eight results being as follows: 0.028%, 0.108%, 0.026%, 0.032%, 0.044%, 0.029%, 0.040%, 0.035%.

The carbon content of the nails is somewhat lower and the sulphur content higher than is commonly associated with ordinary bessemer steels. Dr. PERRET, who sent us the nails, stated that they were probably imported from France, and in view of their phosphorus content and the fact that between 1895 and 1900 France was producing 500,000 to 900,000 tons of acid bessemer steel annually, the nails may have been made by that process even though the basic bessemer is latterly more prevalent in France.

The variable nitrogen content of the nails was quite unexpected. Nitrogen ranged from 0.026% to 0.108% in individual nails, and in the majority of the samples it was considerably in excess of the nitrogen normally found in present-day commercial steels. It would seem, then, that the original content of the steel was increased in some manner by conditions which existed either during or following the eruption of Mont Pelee. Speculations as to the mechanism of the nitrification will be made later.

It might be suggested that the original sulphur content of the nails had been enriched by exposure to hot sulphur-bearing gases. However, under such conditions a high sulphur scale would be formed. Since the actual sulphur content of the scale was not sufficient to justify

such an assumption, the only alternative is that the scale was formed in a relatively sulphur-free atmosphere. Under these conditions the scale formed by the oxidation of a high sulphur steel would lose most of its sulphur to the surrounding sulphur-free atmosphere. In support of this statement it has been found by trial that low sulphur steels heated in an atmosphere containing an appreciable amount of sulphur will form a scale with many times the sulphur content of the steel. On the other

Fig. 2 — Unusual Microstructure Found in Some Nails; 0.026% Nitrogen, by Micro-Chemical Analysis. Etched with 4% nital and magnified 100 diameters

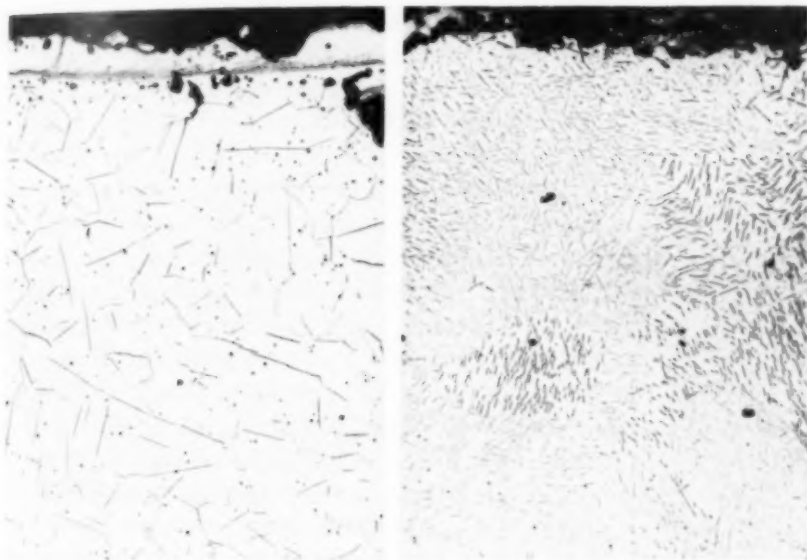


Fig. 1 — Microstructure of One Nail Showing "Normal" Appearance of Nitride Plates. Etched with 4% nital, magnified 100×

hand, scale formed on high sulphur, free cutting steels in a sulphur-free atmosphere generally has very low sulphur.

Unusual Microstructure — Perhaps the most interesting feature of this investigation was the unusual microstructure of the nails. Although the preliminary chemical analysis made by Mr. HARMON indicated a rather high nitrogen content, the nitrides were not present in the usual long plates, but as a dispersion of short plates arranged in a fine Widmanstätten pattern. In view of the fact that uncommon structures were found, it seemed advisable to corroborate the results with chemical determinations.

Of the nails available, several random pieces were selected for metallographic examination. Selection was made from

nails which existed singly but which showed evidence of having been broken from a larger cluster. Although there was no indication that any of the single nails may have come from the same original cluster, only two types of structure were found. Figures 1 and 2 compare these two structures at 100 diameters. In one case the nitride plates were the usual long type distributed through a medium-coarse grain structure.

In these nails, a distinct but rather poorly developed or badly oxidized "case" was found. The other structure was unique in that the nitrides were present as a fine dispersion of short plates in a rather coarse grain structure. Nails with this structure were considerably more ductile than those which contained the long plates. It does not require a great amount of nitrogen to form the microstructure of Fig. 2, for nitrogen as analyzed in another nail having the same structure as Fig. 2 was 0.026%.

Figure 3, page 524, shows the structure of the short plates in Fig. 2 at 1000 diameters. The fine and regular Widmanstätten pattern is clearly outlined. This is a unique structure

for nitrides in steel and must be the result of a rather unusual combination of conditions. A pattern of this type has usually been found to be associated with a certain critical cooling rate from high temperatures.

No definite reasons can be advanced for the differences in the structures of the nitride plates. It might be suggested that they are associated with different rates of nucleation, but whether such differences in nucleation rates are a function of the composition or of the rate of cooling is not known. However, since the two structures can occasionally be found in certain areas of the same sample — with one or the other predominating — it seems more logical to assume that the rate of cooling is not the governing factor. If a difference in composition is responsible for the two structures, this difference may be in the original composition of the matrix or in the composition of the precipitated phase. Although no definite conclusions will be drawn, it should be mentioned that under polarized light the long plates had a slight orange color while the short

ones were slightly yellow. Thus there is some indication that two different nitrogen compounds are present.

Source of Excess Nitrogen still remains highly speculative. A number of interesting possibilities present themselves. However, there are three basic theories which could readily explain the presence of nitrogen in the concentrations observed — one, that the nails originally contained these nitrogen contents; two, that nitrogen from some extraneous source was added to the nails; and three, that the concentration of nitrogen in the nails was increased by preferential oxidation of iron and other elements which decreased the volume of metal without loss of total nitrogen.

It does not seem likely that the nails originally contained the nitrogen concentrations

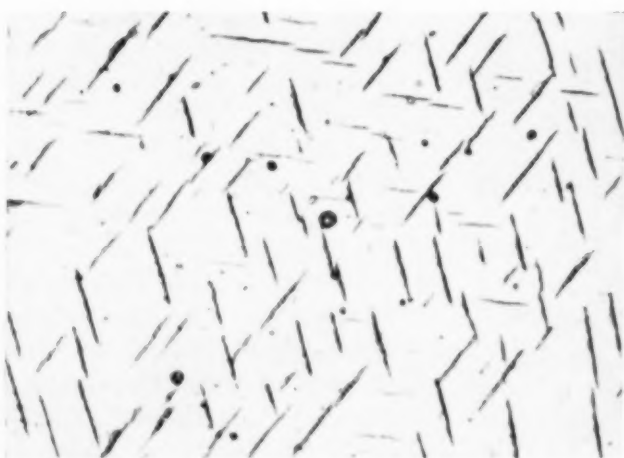


Fig. 3 — Structure of Fig. 2 at 1000 Diameters. Widmanstätten pattern of nitride plates is fine and regular, a structure usually associated with cooling at critical rates from high temperature

found by us. Bessemer steels now made commercially seldom contain more than 0.020% nitrogen, and the highest values recorded in the literature have all been less than 0.030%.

If some extraneous source was responsible for the nitrogen contents of these nails, as suggested by the second hypothesis above, it is possible to think of a number of ways in which nitrification could have been accomplished. Extraneous sources could be either associated with the volcanic action or with the presence of nitrogenous materials in contact with the nails.

There is abundant evidence that nitrogen and compounds of nitrogen are present in the material from volcanic eruptions. E. G. ZIES of the Carnegie Institute's Geophysical Laboratory in Washington reported the presence of

ammonia in a sample of water taken by Dr. PERRET from a lake on Mont Pelee. Furthermore, it is known that severe electrical disturbances accompany a *nuée ardente*. Prof. R. T. HILL reports in *National Geographic Magazine* (Vol. 13, 1902) that he saw "vivid and awful lightning-like bolts which flashed with alarming frequency. . . These were different from lightning in that the bolts were horizontal and not perpendicular." Electric discharges in a mixture of nitrogen and hydrogen will form ammonia, or, in the presence of hydrochloric acid, ammonium chloride can be produced. (Hydrogen chloride is known to exist in gaseous emanations from volcanoes.) At any rate, the existence of ammonia or nitric acid might be suspected from such high electric potential.

Assuming that nitrogen present in the atmosphere of a *nuée ardente* is in an active form, differences in the degree of nitrification might be accounted for on the basis of differences in the original composition of the nails, or of differences in the length of exposure to the activated nitrogen. Nails from the same lot might reasonably be expected to vary in composition, but it is less probable that the variation should be of sufficient magnitude to markedly affect the degree of nitrogen absorption. On the other hand the relative position of different nails in storage bins could well account for the observed differences in nitrogen content. It is doubtful if nitrogen would penetrate an appreciable layer of continuous scale such as was present on the nails; however, the nitrogen may have been absorbed prior to the formation of any quantity of scale, and diffused into the steel while the scale was being formed. This hypothesis, however, necessitates the assumption that the surface fixation of nitrogen occurred very rapidly. Since there is insufficient evidence to warrant such an assumption due to the very rapid passage of the *nuée ardente*, it must be concluded that in spite of the presence of nitrogen compounds in the gases, these gases probably were not responsible for the high nitrogen content of the nails.

Discarding, then, the theory that the volcanic action provided an extraneous source of nitrogen, there remains the possibility of contact with some nitrogenous material. We understand that the nails were gathered from various parts of the city, but at the time of the disaster were located in stores or warehouses which may have been wooden structures. Also, it is possible that a number of other substances were

stored in the same warehouses. It may not be too much of a presumption to suppose that there were kegs of cyanide or bags of fertilizers nearby. When the *nuée ardente* hit the building with hurricane force, it collapsed and the materials stored there were buried in a mass of debris. All of this caught fire and probably burned for days. The nitrogenous material was vaporized by hot volcanic gases and dust, or later by heat from the burning building.

This might be the logical explanation for the nitrification except for the one qualification that the nitrogen had to be fixed on the surface of the nails *before* the scale formed. Results of this investigation, as reported in February METAL PROGRESS, indicate that the scale was essentially free from nitrogen and that the nails were relatively high in nitrogen. We also find that the amount and distribution of the total nitrogen in the steel varied from nail to nail, being in general highest in nails having the smallest cross-sectional area. We know of no published data concerning the penetration of iron oxides by nitrogen, although it has been fairly well established that nitrogen does not diffuse through slags such as are normally used in steel making. If it is assumed, then, that nitrogen will not diffuse through iron oxides, the nitrogen present in the nails must have been there *before* the formation of the scale.

The above conjectures, assuming the presence of an extraneous source of nitrogen, are possible but do not seem very probable. Therefore, an attempt was made to visualize some plausible mechanism which would cause a marked increase in nitrogen content. The most promising explanation evolved was that no nitrogen was added to the nails but that the original nitrogen content remained concentrated in the smaller volume of metal progressively left behind as surface scaling proceeded. The high nitrogen at the residual core would then be explainable not by a gain of nitrogen from the outside, but by a reluctance of the nitrogen to go outside.

Auto-Nitrification During Scaling

During the oxidation of steel at high temperatures, iron and carbon and certain other elements combine with oxygen and a scale is formed. It is probable that nitrogen will not

readily diffuse through an appreciable continuous layer of scale and therefore any of this gas either dissolved or combined with iron will remain in the metal. Since there is a loss of iron and other elements at the surface with little loss of nitrogen, the relative nitrogen content of the steel near the surface is increased, and, in effect, a nitrogen concentration gradient is created, surface to center. Nitrogen will under these circumstances diffuse toward the center of the hot metal, and is concentrated in a progressively smaller volume of metal as oxidation proceeds. The result is that the relative nitrogen content of the metal remaining is gradually increased. Such a mechanism explains the high nitrogen content of those nails with the smallest cross-sectional area.

In order to secure experimental data to support the above reasoning, samples of 5/8-in. steel bar were heated in an open furnace at 2100 to 2200° F. (1150 to 1200° C.) for 24 and 72 hr. Scale was then broken away and the remaining metal analyzed for nitrogen, both turnings from the surface, and 1/4-in. drillings from the axis. Results are shown in the accompanying table.

Migration of Nitrogen During Scale Formation

HEAT TREATMENT	NITROGEN CONTENT	
	AT CENTER	AT SURFACE
Original bar (normalized 1 hr. at 1700° F.)	0.0118%	0.0113%
After 24 hr. at 2100 to 2200° F.	0.0143	0.0166
After 72 hr. at 2100 to 2200° F.	0.0186	0.0198

The gradual increase in nitrogen content will be observed. Several types of steel covering a range of steel making practices have yielded similar results.

Figure 4 (page 526) shows the metallographic structure resulting from furnace cooling after 72 hr. at 2100 to 2200° F. This structure is evidently related to the one shown in Fig. 2. In addition it will be noted that there is an area at the surface which did not etch; this zone may indicate the beginning of a case such as the one shown in Fig. 1.

These experimental results seem to indicate the actual mechanism which produced the unusual nitrogen contents of the nails. Although a pronounced case was not developed in this treatment, it was noted, when the samples were cut with a hack saw, that a certain amount of superficial hardening had taken place. It is

quite possible that either a higher temperature or a longer time at temperature might result in the development of a case equally as pronounced as the one in the volcanic nails.

The question of the role of atmospheric nitrogen in the preceding experiment might still be raised. In order to determine whether atmospheric nitrogen is an important factor influencing nitrogen pickup during high temperature oxidation, a specimen of low carbon steel was held in an atmosphere of pure oxygen for 72 hr. at 2100° F. A carbon combustion furnace was used, and the flow of oxygen regulated to prevent rapid oxidation of the specimen.

At the beginning the surface of the $\frac{5}{8}$ -in. bar analyzed 0.0118% nitrogen and $\frac{1}{4}$ -in. drillings from the axis analyzed 0.0116% nitrogen. After oxidation the surface analyzed 0.028 and the center 0.015%. Thus, the relative nitrogen content of the specimen was increased after a scaling treatment although additional nitrogen could not have been obtained from the atmosphere surrounding the sample.

Such data indicate that a large part of the nitrogen from the oxidized metal diffused into the remaining metal rather than escaped into the scale which formed.


Summary and Conclusions

The main points of interest in this investigation have been the nitrogen contents of the nails examined and the probable temperature to which they were exposed. In order to study these factors, consideration has been given to the possible conditions to which the nails might have been subjected during and after the destruction of St. Pierre by the eruption of Mont Pelee. Concerning the nitrogen, the possibility of an extraneous source has been considered; it has been pointed out that while it might be logical to assume the presence of nitrogenous materials in the same building with the nails at the time of the disaster, nitrification by such a mechanism involves a number of variables. On the other hand, it has been shown

that a process of auto-nitrification can take place at high temperatures, apparently due to preferential oxidation of iron and carbon at the surface. This results in an increase in the relative nitrogen content of the remaining steel. Such a reaction would cause the residue of steel nails, originally with very low nitrogen, to finally contain a greatly increased nitrogen concentration after prolonged exposure to oxidation at a high temperature.

Although a number of nails were examined, only two different microstructures were observed. The one structure was conventional for nitrides in steel; the other was quite unexpected and proved very interesting. Reasons for the precipitation of nitride plates in a fine Widmanstätten pattern are not clear, but there is some indication that their chemical composition influences the mechanism of precipitation.

The actual temperature to which these nails were exposed is difficult to estimate. There is no reason to assume that all of the nails were subjected to the same temperature, as some could very well have been protected from direct heat and therefore would not reach the maximum temperature; these would oxidize at a slower rate. A theoretical consideration of the nature of the scale indicates a probable temperature of at least 2000° F. (1090° C.). By considering the analysis and the condition of the steel nails, a temperature of about 2300° F. (1260° C.) does not seem unreasonable. As an approximation, therefore, it can be estimated that the temperature was in the vicinity of 2150° F. (1175° C.); this conjecture, however, does not preclude the possibility that it may actually have been

higher. Since to all appearances the nails were heated for a considerable period of time, it does not seem reasonable that the temperature of the *nuée ardente* was an important factor. The most logical assumption is that the source of heat was the burning of the building in which the nails were stored — this conflagration, of course, being caused by the passage of the *nuée ardente*. 

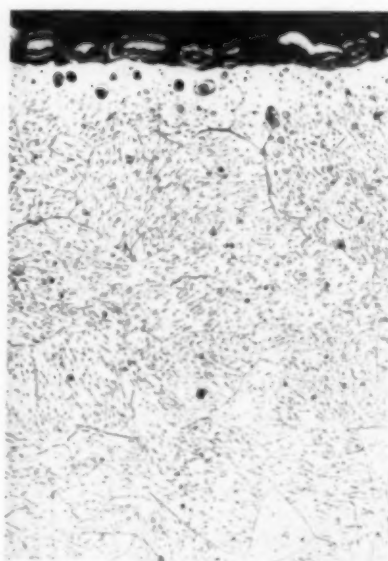


Fig. 4 — Microstructure Resulting From the Oxidation of a Steel Sample For 72 Hr. at 2100 to 2200° F. (1150 to 1204° C.). The nitrogen content in this area is about 0.020%. Magnified 100 ×

North West

Foundrymen

Compare Notes

Annual Conference Reported

By Joseph F. Oesterle

Chairman, Department of
Mining and Metallurgy
University of Wisconsin

SIXTEEN round table conferences featured the two-day foundry conference, the fifth to be held by the Wisconsin Chapter of the American Foundrymen's Association and the College of Engineering of the University of Wisconsin. No formal record was made in any of these meetings, but the 500 men in attendance were pretty generally taking notes.

Aside from these meetings, a general symposium on ordnance brought out the most interest. Lt. Col. BARRETT ROGERS, chief of the artillery division, Chicago Ordnance District, mentioned that small arms use no castings (this includes up to 40-mm. anti-aircraft), but he believed that high strength malleable might substitute for some steel. For heavier guns, the predominant casting material is steel; some non-ferrous is used, but very little gray iron or malleable. Opportunity for cast ammunition is great. The British have purchased several cast steel bombs; while we have none at present, Col. ROGERS suggested that these might come because of shortages in other material. British 3-in. trench mortars are also using a 10-lb. cast steel projectile, and we may use the same in our 81-mm. projectile. Grenades, both hand and rifle, are made of gray iron and any gray iron foundry can make these. Just now the need for cast steel is so great that other foundries are looking for easy ways to convert to steel, but it

is rather expensive to erect openhearth — crucible and converter processes are not allowed.

Lt. A. L. SPURLOCK (formerly production manager for Studebaker) is now in charge of tank production in the Milwaukee area, and spoke interestingly on his problems. There are over a hundred different pieces of cast steel armor ranging in weight from 3 lb. to 11,000 lb. Comparatively few foundries are in this business and most of these have built up their governmental contacts by their own initiative. However, the need is so great now that any foundry with the proper equipment can get the necessary help to start. Many thousands of tanks are needed. There are 500 tank castings other than armor being made, ranging from $\frac{1}{4}$ lb. to 300 lb.

Several well-attended conferences discussed pattern making, properties of sands, and some aspects of foundry work other than metallurgical. A. F. PFEIFFER of Allis-Chalmers Mfg. Co. gave an interesting account of his efforts to bring foundrymen and patternmakers together — an extension of the continued necessity for purchaser's engineers and foundry representatives to confer before any new design reaches blueprint stage. PFEIFFER uses sectionalized models of the intended part, and this model is studied from all angles and molding methods agreed upon before (*Continued on page 562*)

Iron Powder and Its Sintering

By J. Libsch
R. Volterra
and John Wulff

Mass. Institute of Technology

DEVELOPMENT of iron powder for powder metallurgy purposes has received considerable industrial attention. Some 28 American organizations were producing powder or experimenting with methods of production in 1940. Some of these organizations as well as their customers realize that size distribution and chemical analyses are insufficient to describe the quality. Likewise, the maintenance of a supply of powder of constant quality has not proven to be an easy task. Perhaps a short account of the manufacturing processes may serve to illuminate some of the differences reported in the sintering qualities of various powders.

The oldest and the most widespread commercial method is by reduction of iron oxides. Such oxides may be concentrated magnetite ore, by-products such as mill scale or partially oxidized iron scrap borings, turnings and the like. Reduction is usually accomplished in an atmosphere of CO and CO₂ between 1650 and 2000° F. by batch or continuous processes. The atmosphere may be produced in many different ways starting with solid, liquid or gaseous fuels admixed with air. The addition of hydrogen to the reduction gas, as well as its use in subsequent annealing, alters the nature of the powder besides affecting its purity.

The raw material is usually first pulverized by milling and then reduced to a powder or a sinter cake, which is more or less easily crushed. Depending on the temperature, the initial size, structure, and purity of the oxide, the time of

heating, the gas used and the amount of milling and subsequent finish annealing, the powder particles may be distinguished from one another by (a) particle size, (b) particle shape, (c) surface profile, (d) type and extent of porosity, (e) internal grain size, (f) lattice distortion within each particle, and (g) impurities present and their location, whether in solid solution, as large inclusions, or as surface and grain boundary films. Obviously the investigation of each of these factors separately and together and their relative importance is an arduous task.

In general, the reduced iron successfully compacted is more or less angular in shape, of rough surface, porous, and made up of a small number of micro grains within each particle. The particle size limits are usually between 48 and 500 mesh. The pressure needed and the heat treatment cycle depends on the porosity of the particles, the smoothness of their profile, and on the distribution of the finest sizes. For example, we have found that the reduced oxide of Fig. 1, consisting of fairly dense, more or less rounded particles (in comparison with the more angular reduced oxide particles of Fig. 2) required higher pressures to compact to equivalent density and a longer heat treatment cycle to reduce asymmetric shrinkage and expansion to a minimum. Superficial oxidation of the smooth particles with steam followed by a short subsequent reduction in hydrogen improved the pressing characteristics of the first mentioned powder.

Usable powder can also be produced from comminuted steel or cast iron. Some oxidation with steam is sometimes a first step, but final

decarburation is usually in a CO-CO_2 atmosphere — an exothermic process by which the powder may be reduced to exceedingly low carbon. When decarbured from crushed cast iron the particles often resemble reduced oxide, but elongated and flat particles are more common. Here the original carbide structure, the conditions of decarburation, and the post treatment affect the powder characteristics. Where powders of this sort are mixed with reduced oxide powders before pressing, it is often only necessary to decarbure superficially and to convert the cementite into a form which leaves the particles reasonably soft. Likewise, finely divided, low carbon, thin sheet scrap has been milled by special techniques aiming to produce equiaxed rather than plate-like particles. It is difficult to compress such particles unless previously softened by heat treatment. Here again superficial oxidation and reduction vastly improves the sintering qualities.

Iron powder produced by electrolytic methods can be made of high purity and also of excellent pressing qualities. When deposited as powder and sized, it consists of nodular remains of dendrites. The internal structure is always fine grained. When deposited as a sponge (Fig. 3) it can be crushed to angular particles of various sizes, but, as in the previous case, it is not readily compressed into briquettes. It can be softened by annealing, due to the removal of the occluded hydrogen and the increase in the

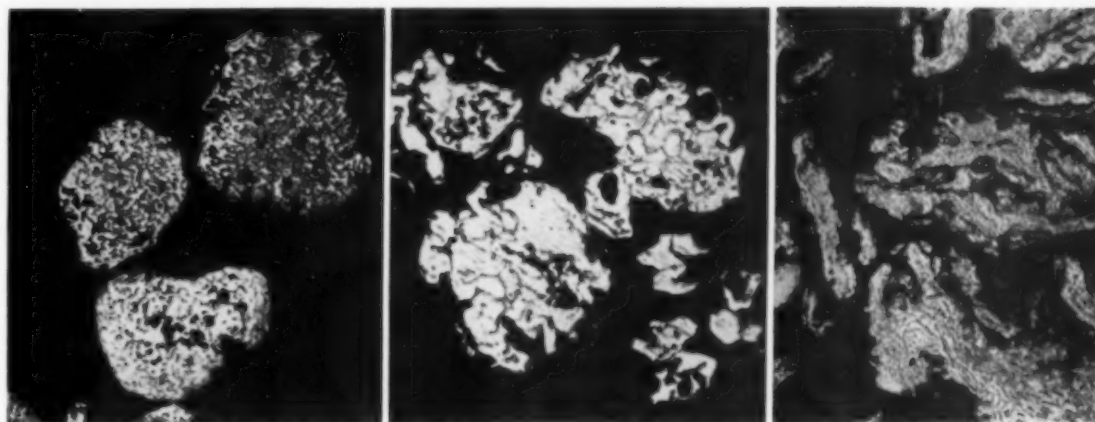


Fig. 1 to 3 — Various Iron Powder Particles, at 200 Diameters, Left are smooth particles reduced from mill scale. Center are rough particles reduced from magnetite ore; this powder requires less pressure and shorter sintering. Right are spongy electrolytic particles; they are improved by annealing in hydrogen

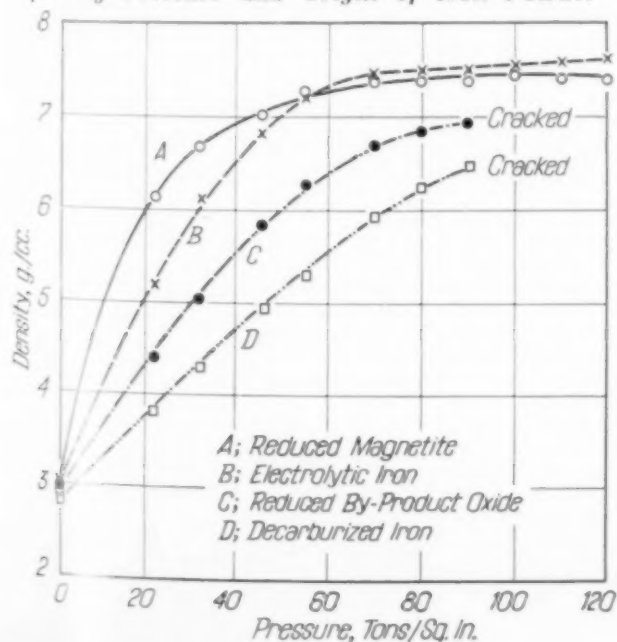
internal grain size. The powder shown in Fig. 3, when compressed above 30 tons per sq.in. in a simple steel die, fails by shear and the compact crumbles readily when ejected from the die. If this powder is annealed in hydrogen at 1300 to 1500° F. for 2 hr., and the sinter cake disintegrated with soft rubber tools, it can be compressed easily to form satisfactory compacts at 30 tons and will withstand compression in a simple die up to about 70 tons per sq.in. If annealed in a vacuum it will withstand pressures over 120 tons per sq.in. This improved behavior can be attributed primarily to the more thorough removal of occluded hydrogen.

Carbonyl iron, although only used in this country for electromagnetic purposes, is also employed abroad for sintering purposes. . . .

Pressing — The purpose of pressing in powder metallurgy is not only to form a compact of definite shape, but also to produce strong adhesion bonds at the contacts between adjacent particles. Thus, the pressed compact coheres not only because of interlocking particles but also by interatomic attraction. This may be termed "cold welding" and may be considered an example of "sintering". With relatively soft powders, such as iron, the area of contact is greatly influenced by the deformability of the particles. Within limits, coarse sizes of angular iron powder give more dense compacts in definite pressure ranges. It should be remembered that the distribution of pressure in a die is not uniform; consequently density gradients in the pressed compact are usually found to be more acute for harder powders.

In Fig. 4 are shown curves of density versus compacting pressure for four different commer-

Fig. 4 — Density of Compacts Varies With Compacting Pressure and Origin of Iron Powder



cial powders. They were pre-annealed at 1350° F. in hydrogen, compressed from both sides in a small steel die, from which they were removed by hand. In each case, the powder size distribution used was 66% coarse (100 to 200 mesh), 17% medium (200 to 325 mesh) and 17% fine (—325 mesh). Powder A is a reduced magnetite, porous, angular and rough. Powder B is of electrolytic origin. Powder C was reduced from mill scale and differs from A in that it is more equiaxed, smoother and less angular. Powder D is a decarburized iron, angular and irregular in shape but less equiaxed than powder A. All powders were polycrystalline, but powder particles of B were made up of smaller grains than the rest.

Chemical purity of powder B was, of course, the best. All contained less than 0.03% carbon. The insolubles of A totalled 0.96%, of C 0.56% and of D 0.86% (primarily as iron silicate). Powder D, made from a shotted cupola scrap melt, contained 0.23% Cu, 0.05% Sn, 0.18% Si, 0.96% Mn, 0.64% Cr, 0.87% Ni, 0.05% S, 0.02% P, and traces of Sb and Pb.

Powders A and B are clearly superior in this test. The lower green density of powder C compacts can perhaps be attributed to round particle shape and smooth surface, while that of D to impurities. A higher percentage of coarse powders will produce a greater green density in all four varieties. On subsequent heat treatment, shrinkage is greater if a higher percentage of fines is used than employed here.

Density of the pressed compact may be used as a qualitative measure of the plasticity of the

powder, and thus of the contacting area between the particles, but it is not necessarily an indication of the strength of bonding. . . .

Pressing Followed by Heat Treatment—Compacts made under usual conditions were then heated at various temperatures in hydrogen and the bars tested for density, tensile strength and elongation. Electrolytic iron (whose particle size analysis was 66% 100 to 200 mesh, 17% 200 to 325 mesh and 17% through 325 mesh) reached maximum density and tensile strength (30,000 psi.) at 1550° F., with elongation of 15%. All properties dropped, reaching a minimum at 1700° F., but then more than recovered at 2200° F.

Experiments with the other three powders do not show as high a tensile strength and elongation, but also not as severe a minimum at 1700° F. All three only reach a tensile strength at 2200° F. comparable to the strength of electrolytic powder for a 1550° sintering temperature. Furthermore, these three powders do not show the same excessive grain growth at 1550° F. that the electrolytic powder, carbonyl and milled powder do.

[Effect of time at sintering temperature was also investigated. Representative results for electrolytic iron show little improvement after 4 hr., say at 1550° F., except a slight improvement in elongation, which reached 20% after 24 hr.]

Recrystallization and Grain Growth—A series of photomicrographs showing grain growth in electrolytic iron are shown in Fig. 5. In Fig. 5a the deformed structure due to compression at 33 tons per sq.in. is evident. Recrystallization in particle boundaries and within particles is apparent after sintering at 1155° F.—see Fig. 5c. At 1380° F. an entirely new structure is evident—see Fig. 5d, but some noticeable grain size contrast makes it difficult to say that the old particle boundaries have been completely obliterated. Grain growth is excessive between 1515 and 1650° F. in electrolytic powder: Fig. 5f shows grains many times the size of those found in reduced magnetite powder after the same treatments.

SAUERWALD finds the temperature of excessive grain growth to (Cont. on p. 540)

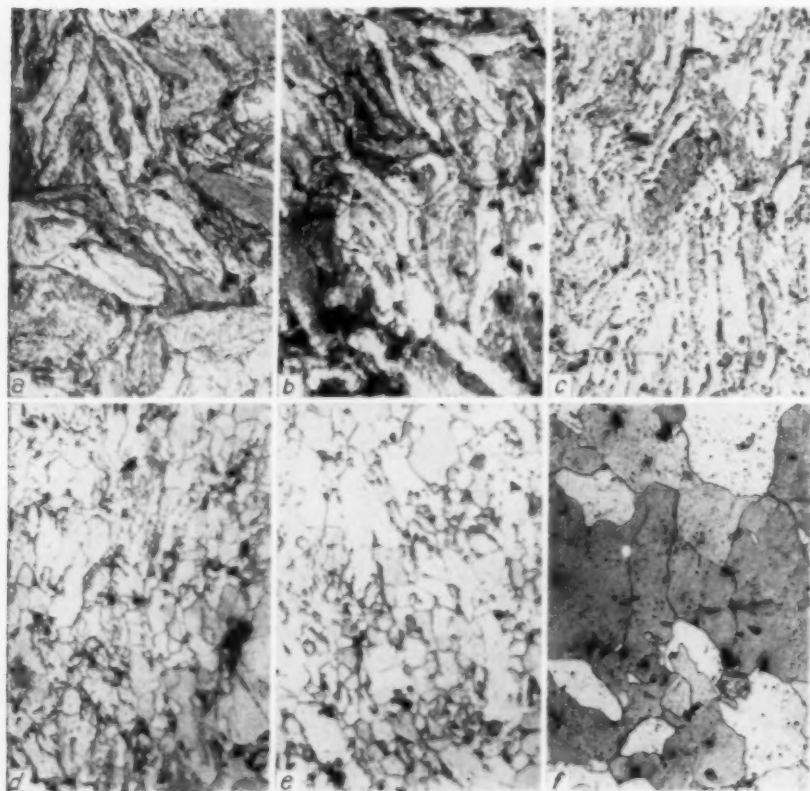
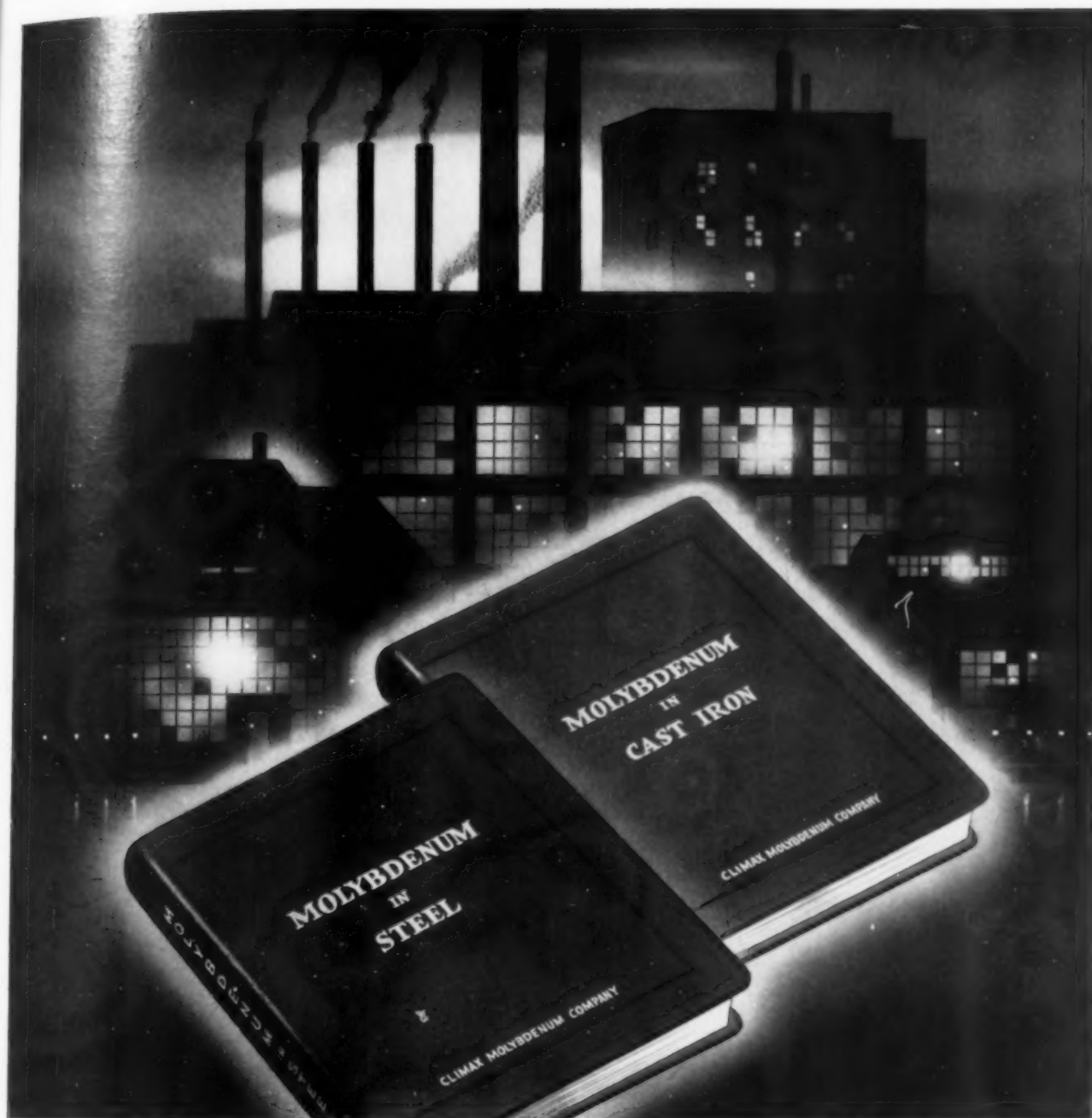


Fig. 5 — Grain Growth With Increasing Sintering Temperatures. 150×. Electrolytic iron, compacted at 66,000 psi., heated 4 hr. in dry hydrogen; a, as pressed; b, 930° F.; c, 1155° F.; d, 1380° F.; e, 1515° F.; f, 1650° F.



PRACTICAL DATA FOR PRESENT PROBLEMS

Here are two books designed to help users of Molybdenum steels and irons to conserve all alloying elements, and possibly steel and iron, by getting the most in the way of strength, toughness and wear resistance with the lowest alloy content.

"**MOLYBDENUM IN STEEL**" covers the fundamental metallurgy of Molybdenum steels. Heat treat-

ment - physical properties - applications - of a number of these steels are treated at length.

"**MOLYBDENUM IN CAST IRON**" covers the effect of Molybdenum in gray iron, giving suggested analyses for practical applications and detailed discussion of high strength (60,000 p.s.i. and up) irons.

Both books will gladly be sent free on request.

CLIMAX MOLYBDENUM COMPANY
500 FIFTH AVENUE • NEW YORK CITY

Personals

John S. Marsh ☉, editor of Alloys of Iron Research of the Engineering Foundation, has resigned to accept a position with the research and development department of Bethlehem Steel Co.

Raymond Vines ☉ is now metallurgist at the Ford Instrument Co., Long Island City, N. Y.

J. R. McCarron ☉ has been appointed Philadelphia manager for Vanadium-Alloys Steel Co.

Herbert J. French, national vice-president, ☉, who has charge of alloy steel and iron research at International Nickel Co., Inc., has been appointed senior technical consultant in charge of the Metallurgical and Specifications Section of the Iron and Steel Branch, War Production Board.

Promoted by Peter A. Frasse & Co., Inc.: Russell B. Barnett ☉, formerly Buffalo branch manager, to Philadelphia branch manager; Leslie N. Stetson ☉, formerly sales representative, to Buffalo branch manager.

Transferred: Fred J. Herr ☉, from the metallurgical department of the Vanadium-Alloys Steel Co. in Latrobe, Pa., to the Cincinnati sales office.

Weld Conley ☉ is now employed as civilian engineer by the Naval Ordnance Laboratory, Washington Navy Yard, Washington, D. C.

Barnet D. Ostrow ☉ is now research chemical engineer in charge of research and development at Benrus Watch Co., Waterbury, Conn.

James J. Bowden, Jr. ☉ is now a member of the U. S. Navy, and is stationed at the Naval Training School for Radio, Noroton Heights, Conn.

Manley W. Mallett ☉ is connected with the Owens-Illinois Glass Co., Packaging Research Division, as research chemist.

Glenn L. Brock ☉ is now with Hollywood Heat Treating Co., Hollywood, Calif.

John Wulff ☉, professor of metallurgy, Massachusetts Institute of Technology, was recently guest lecturer on powder metallurgy at the Toronto meeting of the Canadian Institute of Mining and Metallurgy.

Thomas J. Donovan, Jr. ☉ has severed his connection with Hill Chase Co. as manager of the tool steel department, and formed a partnership with M. B. Berryman known as Donovan-Berryman Co., Philadelphia.

George L. Mitsch ☉ has resigned from the American Car & Foundry Co. and is now employed as production assistant, Special Products Division, the Midvale Co., Philadelphia.

WHEN MACHINING BULLET CORES...



• The experience of the pioneer manufacturers now using skillfully developed applications of

Stuart's

Thred-Kut

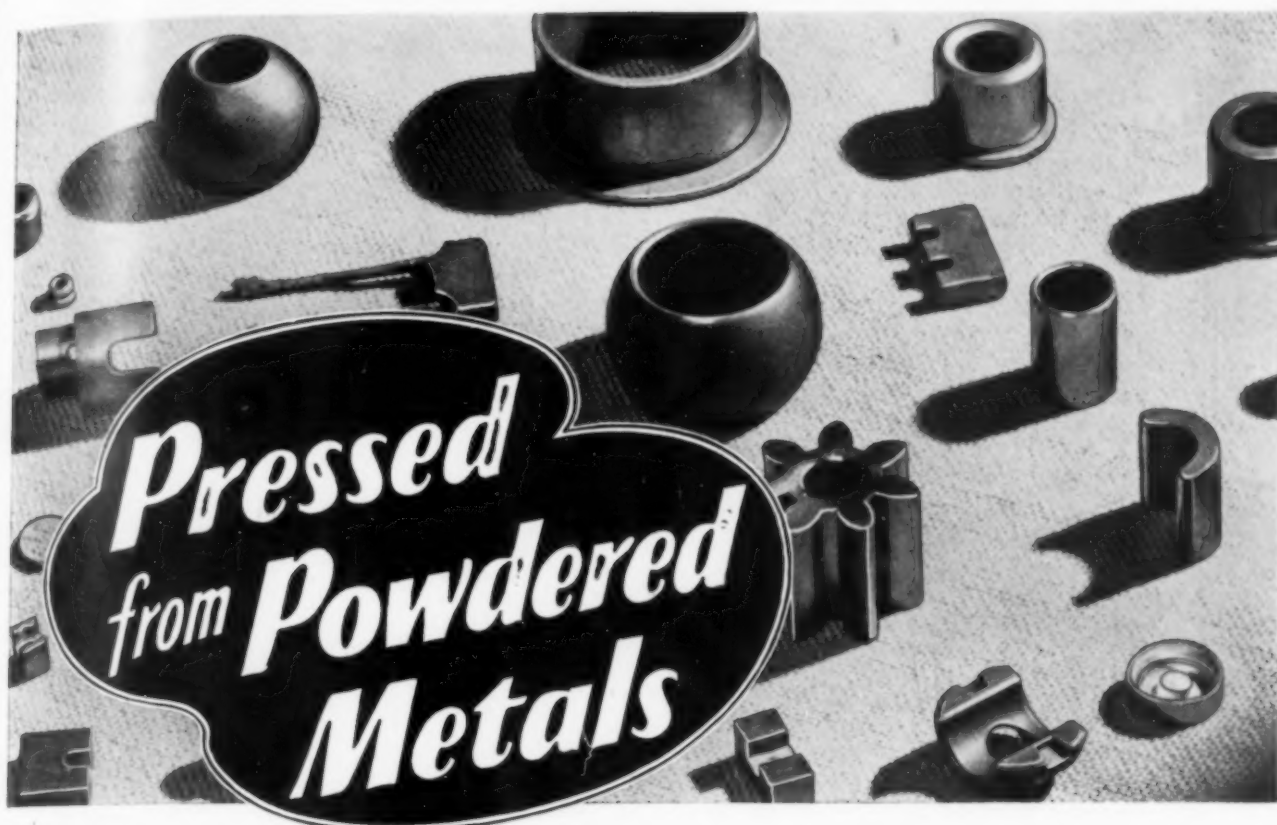
PAT. U. S. PATENT OFFICE

is available, upon request, to new prime or sub-contractors just starting.

**...the selection
of the right
cutting fluid
first will save
time, tools
and scrap!**



For All Cutting Fluid Problems
D. A. STUART OIL CO.
Chicago, U.S.A. • LIMITED • Est. 1865
Warehouses in All Principal Metal Working Centers



Parts Like These In One to Two Seconds

Like many other materials powdered metals lend themselves readily to compressing. Finished products can be completely formed, ready for sintering, in a matter of seconds. Production rates of 10 to 50 or more per minute are usual for parts such as copper motor brushes, porous bearings, contact points, etc. Rates of several hundred per minute are often possible, depending on the size of the part, its form, material and pressure required and the machine used.

With Stokes Automatic Presses, developed especially for compressing powdered metals, intricate as well as simple parts are being produced . . . half bushings, thin rings, flanged bushings, Alnico magnets, iron radio cores, iron gears, etc. These parts are dense and of uniform accuracy, made under identical conditions of fill and pressure. Density is accurately controlled, with pressure applied from top and bottom simultaneously or separately as may be required.

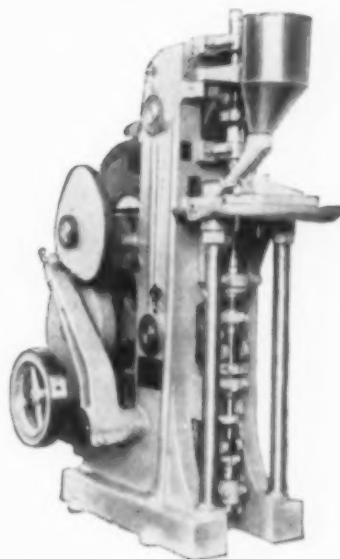
Stokes Presses for powder metallurgy are rugged, powerful, practical and productive . . . the result of many years of research and development work with engineers in this field. Built into them is our more than 40 years' experience in the manufacture of automatic press equipment for forming chemicals, explosives, pharmaceuticals, ceramics and other materials.



New, complete 48-page catalog is now ready. Describes advantages of Eccentric, Cam-operated and Rotary presses. Shows presses up to 300-tons capacity and hundreds of parts made by compressing. Contains valuable information for reference. Write for your copy.

F. J. STOKES MACHINE COMPANY
6006 Tabor Road Olney P. O. Philadelphia, Pa.

Representatives in New York, Chicago, Cincinnati, St. Louis, Cleveland, Detroit
Pacific Coast Representative: L. H. Butcher Company, Inc.



Model "S" Press, a general-purpose machine, applies 30 tons pressure. Output up to 35 pieces per minute.

F. J. Stokes

**AUTOMATIC
TABLETTING EQUIPMENT**



Personals

Harold H. Strauss ☉ has accepted a position as senior stress analyst in the Northrop Aircraft Co., Inc., Hawthorne, Calif.

Robert E. Montbach ☉, formerly of Bethlehem Steel Co., has been called to active duty in the U. S. Army.

Robert R. Allen ☉ is now employed as a junior metallurgist in the Materials Laboratory at Wright Aeronautical Corp., Paterson, N. J.

John Conte ☉ and Lewis C. Cavalier ☉, recent graduates of the Pennsylvania State College, are now affiliated with the Mineral Industries Extension Department as assistant supervisors of metallurgy extension.

Ensign J. D. Ruschak ☉, formerly assistant to the engineering superintendent in the assembly and repair department at the U. S. Naval Air Station in Pensacola, Fla., is now in the Bureau of Aeronautics, Navy Department, Washington, D. C.

William H. Bassett, Jr. ☉, technical superintendent and metallurgist, Anaconda Wire and Cable Co., is on active duty as captain in the Ordnance Department with assignment as metallurgical assistant, Industrial Service, Inspection, Office of Chief of Ordnance, Washington.

James E. Davis ☉, formerly an inspector at Jones & Laughlin Steel Corp., is now a junior aeronautical engineer, Aeronautical Materials Laboratory, Naval Aircraft Factory, Navy Yard, Philadelphia.

Cecil N. Hoagland ☉, formerly research and development engineer, the Bullard Co., is now division manager of the Murray Mfg. Corp., Brooklyn, N. Y.

J. L. Spears ☉ is now employed as line supervisor for Canadian Car Munitions Ltd., Montreal.

W. H. White ☉, district manager for Allegheny Ludlum Steel Co. in Cleveland, has been made director of sales for Atlas Steels Ltd., Welland, Ont., Canada.

Called to active service with the Navy Bureau of Ordnance as lieutenant commander: Arden L. Knight, past chairman, Boston Chapter ☉, member of National By-Laws Committee, and formerly sales representative for Latrobe Electric Steel Co. in Hartford, Conn.

A. C. Carlton ☉, curator of fuels and metals, has been given temporary leave of absence from the Museum of Science and Industry, Chicago, for an assignment in the small fuze and primer section, Ammunition Division, Chicago Ordnance District.



Bombs Bursting in Air *Elastuf Type A*

Imagine a stock machinery steel strong enough to resist artillery bombardment. That is the routine duty of ELASTUF TYPE A Heat Treated Alloy Steel, in this explosive test bomb, with which engineers test shattering powers of high explosives. The cylinder must withstand violent shock, tremendous pressures,

must retain strength in face of abnormally high temperatures, and offer complete safety. Dependable PERFORMANCE recommended ELASTUF TYPE A for this bomb—the same performance that has suggested this steel for many arduous jobs.

Send for this booklet

"ELASTUF STEELS in ACTION"

This booklet gives you many other cases showing how all ELASTUF Steels are meeting problems of application and service. It contains a copy of the famous MACHINERY STEEL SELECTOR, a guide to the right steel for the job. A copy of this booklet is available, without obligation, to all Department Heads in Purchasing, Engineering and Plant Management. Address Machinery Steel Division at the nearest address below.



ELASTUF STEELS

BEALS-McCARTHY & ROGERS • BUFFALO-ROCHESTER
BROWN-WALES CO. • BOSTON, MASS.-LEWISTON, ME.
HORACE T. POTTS CO. • PHILADELPHIA-BALTIMORE

Ready to go anywhere
... QUICKLY

It's reassuring these days to see those sturdy Bell System trucks along the highway.

They are mechanized motor units. Each has a highly skilled crew; each has its own tools, power and materials. They are ready and efficient and can be mobilized anywhere, any time. And there are more than 27,000 of them.

This is just one way the Bell System is prepared to keep lines open and ready for war-time service — no matter when or where the test may come.



BELL TELEPHONE SYSTEM . . . Service to the Nation in Peace and War



England Limits Tungsten in

High Speed Toolsteels

Extracts from
The Engineer
Feb. 20, 1942, p. 159

SHORTAGE in tungsten and cobalt has caused the British Iron and Steel Control to issue an order on Feb. 13 prohibiting the manufacture of high speed toolsteel containing more than 6½% tungsten, except under

specific license issued when it is proved that substitute steels are not suitable. Similar restrictions are placed on the 18% tungsten toolsteels containing cobalt.

"Substitute steels" consist of known and proven compositions,

of which the following are two typical grades:

	SUBSTITUTE 66	SUBSTITUTE 94
Molybdenum	5.0 to 6.0%	8.5 to 9.0%
Tungsten	5.5 to 6.5	3.5 to 4.5
Chromium	4.0 to 5.0	3.5 to 4.5
Vanadium	1.25 to 1.50	1.25 to 1.50

"Users who so far have no experience in molybdenum steels are advised to accept the proved experience in both America and this country that 'Substitute 66' corresponds closely to standard 18% tungsten high speed steel."

The control order contains "specific notes of guidance drawn up partly from American sources and partly from experience available in Sheffield amongst steel manufacturers who have done work on these steels". These notes follow closely the recommendations on heat treatment made by the American committees advisory to OPM, published in METAL PROGRESS, September 1941. The following remarks on segregation of scrap are of further interest:

"Scrap segregation in users' works will be a very real problem, but it is of vital importance to all steel manufacturers. Failure to separate and identify scrap from substitute steels can only lead to trouble when that scrap comes back to the steel works. All steel makers will adopt the standard designations of 'Substitute 66' and 'Substitute 94' respectively when stamping, labeling, and invoicing, in addition to any brand marks. You are earnestly requested, in your own interests and to assist steel manufacturers to carry the heavy burden which the change places upon them, to see that scrap from substitute steels is kept distinctly separate from scrap from high tungsten, high speed steel, is clearly identified, and that this identification follows it right through your works and is associated with all invoices and advice notes when you return scrap to your steel supplier. The less scrap changes hands the less chance there is of mixing; therefore, return it directly to any producer of high speed steel who will always allow you the ruling Ministry of Supply price for it, according to quality."

PRICELESS TIME RUNS FAST

Double Triple its value by
ROTOBLASTING!



Right now—today—TIME IS PRICELESS! Yet TIME is swiftly slipping away—

★ We realize—at the last minute—that DELIVERY OF PRODUCT—both by industry and fighting men—is the only thing that counts in war. All the large and small metal parts that make up our great armament schedule

—all the castings and forgings and heat treated parts used in tanks and ships and guns—must be DELIVERED faster and faster—before time runs out—BEFORE IT IS TOO LATE!

Pangborn ROTOBLAST Tables, Barrels and Special Cabinets—many operating twenty-four hours a day—are cutting blast cleaning time schedules right and left. Gray iron, steel, alloy and malleable castings; forgings; steel products including shells, bombs, armor plate, tank and gun parts are being DELIVERED—TODAY—because of Pangborn ROTOBLASTING.

Can short cuts be opened up for your deliveries—work turned out FASTER—BETTER—AT LESS COST? An inquiry will quickly bring you all the facts. Wire today.

PANGBORN

WORLD'S LARGEST MANUFACTURER OF DUST COLLECTING AND BLAST CLEANING EQUIPMENT
PANGBORN CORPORATION . . . HAGERSTOWN, MARYLAND

THE PROPERTIES OF LEAD

Work Hardening & Resistance to Flexure Failure

A test to measure the increase in hardening due to cold working was devised, and the following results were obtained on various grades of lead and some of its alloys.

DESCRIPTION OF SPECIMEN				INCREASE
Corroding Lead	99.99+%	(.006 Bi)	— Rolled	1%
Common Lead	99.85+%	(.12 Bi)	— Rolled	2%
Corroding Lead	99.998%	(no Bi)	— Rolled	3%
Common Lead	99.98+%	(.002 Cu)	— Rolled	12%
Chemical Lead	99.92+%	(.06 Cu)	— Extruded	9%
Tellurium - Lead		(.06 Te)	— Extruded	26%

These results were obtained with loads of 1100 grams. Extruded calcium lead alloys containing .03% Ca were tested at higher loads, as follows:

	1300 grams	1500 grams	1900 grams	2100 grams	2200 grams
Increase in Hardening	16%	22%	22%	23%	18%

Resistance to failure by bending was tested by subjecting strips of lead under stress of 200 pounds per sq. in. to reversed 90° bends made alternately over 5" diameter rolls at a rate of 11 cycles per minute.

GRADE OF LEAD	PREPARATION OF SPECIMEN	CYCLES TO FAILURE	PERCENT ELONGATION
Common Lead 99.85+%	Extruded	72	49
Chemical Lead 99.92+%	Extruded	103	52
Corroding Lead 99.99%	Extruded	54	35

The properties of work hardening and failure by bending, are of interest where the lead in its application is subjected to cyclic loading or flexing.

Shown at right are lead lined steam separators (4' x 6' 6³/₄") in chemical plant.



ST. JOSEPH LEAD COMPANY

250 PARK AVENUE • NEW YORK • ELdorado 5-3200

THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

NOW MORE THAN EVER *Personal* ATTENTION COUNTS



For 2,200,000,000 "Breaks"

Bendix-Scintilla chooses Aeralloy

In a Bendix-Scintilla aircraft magneto, a pair of contact points must make and break 4 amps at 180 volts 2,200,000,000 times—as a minimum.

A tough job? Certainly. But Bendix-Scintilla finds the answer in Wilco Aeralloy—and

just as Wilco Contact Alloys solve electrical problems so too, do Wilco Thermometals (thermostatic bi-metals) control temperature or give unfailing positive reaction to temperature changes. Write today for the Wilco Blue Book.



The H. A. WILSON CO.
105 CHESTNUT ST., NEWARK, N. J.
Branches: Chicago and Detroit

Why Powdered Metals for Electrical Contacts

Gibsiloy ELECTRICAL CONTACTS

Gibsiloy electrical contact material, produced by means of powder metallurgy, combines metals which cannot be combined by other methods. The resulting materials combine the desired characteristics of the constituent elements. With Silver as the principal ingredient, high electrical and thermal conductivity and low contact resistance are assured, while the following properties may be added as desired:

TOUGHNESS, HARDNESS and LONG LIFE—by the addition of Nickel.

NON-WELDING CHARACTERISTICS—by the addition of Graphite (a non-fluxing element), or Molybdenum or Tungsten (metals with high melting points).

Gibsiloy is highly ductile—consequently can be supplied in almost any shape desired. Write for Catalog C-10, containing complete information on GIBSILOY Electrical Contacts and contact materials.



Manufactured by
GIBSON ELECTRIC COMPANY

8358 Frankstown Ave., Pittsburgh, (21) Pa.

Iron Powder

(Cont. from p. 530) be higher for the iron powder he used, and states that the phenomenon is independent of the pressure, powder size and powder origin. SCHLECHT and his co-workers find, on the contrary, that excessive grain growths occur at 1470° F. in compressed carbonyl powder (1 to 10 μ in size). In our own work we have observed that the temperature of excessive grain growth and the extent to which it occurs is dependent on the powder, its shape, size distribution, purity and origin, and is also dependent on the pressure employed. Of these factors the most important is the *purity* of the powder. This is illustrated by experiments with the powder from reduced magnetic ore (which of course contains the remains of non-metallic mineral impurities). The reluctance with which this recrystallizes suggests that the same conditions are operating as in tungsten, where it is possible to suppress grain growth with addition agents, or to accelerate grain growth by others. It is significant that those powders which exhibit excessive grain growth have a first maximum in strength and density at temperatures slightly below that at which grain growth begins.

Another point needs to be stressed, namely that on heating loose powder masses, powders which recrystallize readily sinter at lower temperatures than powders which are pre-annealed—provided, of course, they are uncontaminated.....

Effect of Particle Size—Foreign workers, studying comminuted and annealed iron powders of different size distribution, report that a powder mix which contained only —200 mesh material when pressed at about 46 tons per sq.in. and heat treated at 2065° F. in hydrogen for 30 min. exhibited higher tensile strength, higher yield point and Brinell hardness than three other powders of coarser size distribution. In every case, excessive grain growth was independent of the powder size.

We made similar studies on pre-annealed electrolytic iron powders, and the trend of our results is similar. Best hardness comes from the finest sizes (325 to 500 mesh); however, best results in other properties come from mixed sizes (66% coarse, 17% medium, 17% fine).

	FINE POWDER	MIXED POWDER
Brinell	45.4	39.4
Tensile	30,000	31,000
Elongation	13.0	16.5
Density	6.90	7.27

We do not wish to emphasize the *particular* size distribution, for some variation in each of the size fractions does not seriously alter the properties obtained. We can nevertheless say that an increase in the percentage of (Cont. on p. 550)

LIST YOUR PRODUCTS BEFORE 20,000 MEN

IN THE METAL PRODUCING AND
METAL WORKING INDUSTRIES
IN THE

METALLURGICAL CATALOG

Thousands of inquiries to advertisers have proved the value and reader helpfulness of the last three editions of the Metallurgical Catalog. They guarantee the advertising effectiveness of the forthcoming 4th Edition.

20,000 copies of this tested buyers' guide for the metal working and metal producing industries insures the broadest coverage of the biggest market in industry today. 15,000 copies will be included in the June issue of *Metal Progress* as the Where-To-Buy section, providing a complete six-month long coverage of the important American Society for Metals membership. 5,000 copies will make up the Metallurgical Catalog printing, and will be placed in the hands of additional executive, engineering and purchasing factors in the metal industry.

The urgent search for sources of metals, methods, products and production equipment insures constant reference to this Catalog. All companies who manufacture products listed are invited to participate, whether they advertise or not, in an effort to create the most helpful and complete buyers' reference for the industry. This policy has paid off in reader satisfaction and in advertising results.

In the new edition to be published in June, **bold-face type** will be provided for the listings of advertisers in the buyers' guide. Advertisers will enjoy two big advantages—the 20,000 circulation coverage of this big industry and prominent **bold-face** listings for their company under all the product headings for which they classify.

Advertising rates for the forthcoming buyers' guide have been geared to economy to permit advertisers to present the complete details of their products.

Hundreds of important manufacturers will be listed—make certain your company dominates under its proper production classifications by reserving advertising space and securing **bold-face** listings now.

Write for folder giving complete details and advertising rates.

**AMERICAN SOCIETY
FOR METALS**

7301 Euclid Ave. Cleveland, Ohio

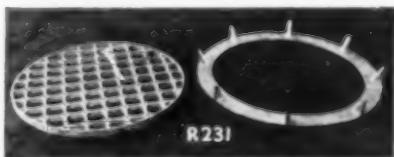
Amsco Alloy Battles on the Industrial Firing Line . . .

To "Keep 'Em Rolling, Flying and Firing" it requires steel and more steel—steel for machine tools—steel to withstand the scars of battle—better steel—which implies heating and heat treatment on a vast scale.

To keep heating furnaces and heat-treating furnaces in constant operation with a minimum of shut-downs Amsco Alloy has "enlisted" in many metal-working plants.

Cast parts of this series of chromium-nickel alloys provide a maximum service life when applied to equipment involving the use of high temperature because

1. There is a grade formulated to withstand various degrees of heat or corrosion, or both.
2. All castings are produced under rigid metallurgical laboratory control.
3. Users benefit from Amsco's experience in designing cast parts that take into consideration metallurgical factors; designs that have been proved in our Experimental Foundry, x-ray laboratory and in actual service.



Charging basket support-grid and seat ring of F-10 alloy for circulating gas fired tempering furnaces.

Amsco Alloy is directly aiding our gigantic war production effort—battling on the industrial firing line—by conserving cast parts less suited to this service and by minimizing maintenance and down time, thereby keeping produc-



Non-cooled shafts and discs of Amsco Alloy grade F-10 for roller bottom furnace in a sheet mill. Heat, abrasion and some corrosion are involved.



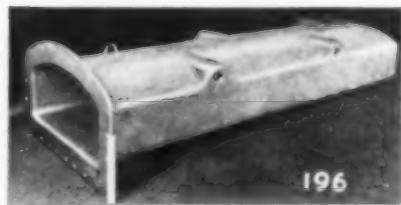
Ingot soaking pit burner tips of alloy F-3; a grade yielding maximum service where temperatures are high but undulating and low load carrying capacity is required.



Hearth plates for a forging-billet heating furnace of Amsco Alloy F-1 which has high strength at 2100° F., but is slightly less resistant to sulphurous furnace fuels than the more generally used grade F-10.

tion at a steady pace and saving manpower.

Bulletin 108 shows what Amsco Alloy is doing for industry and tells of the painstaking care taken in the production of every casting—practices that have resulted in the widespread use of this alloy by heat treaters and furnace builders. A copy may help reinforce your firing line.



Carburizing furnace muffle of grade F-1. Body and end cast separately and welded. Total weight, 1750 lbs.

Amsco
AMERICAN MANGANESE STEEL DIVISION
OF THE AMERICAN BRASS, IRON & FOUNDRY CO.
Chicago Heights, Illinois

FOUNDRIES AT CHICAGO HEIGHTS, ILL.; NEW CASTLE, DEL.; DENVER, COLO.; OAKLAND, CALIF.;
LOS ANGELES, CALIF.; ST. LOUIS, MO. OFFICES IN PRINCIPAL CITIES

Manganese Steel Castings for shocks and abrasion.
Chromium-Nickel Alloy Castings for heat and corrosion resistance.
Power Shovel Dippers. Dredge and Industrial Pumps.
Welding Materials for reclamation and hard-surfacing.

Dolomite Brick*

FURTHER replacement of magnesite and chrome-magnesite bricks by dolomite bricks in openhearth and reheating furnaces would reduce the strain on shipping and free magnesite for positions in which its use is at present essential. Successful

experiments along this line on a works scale were made in 1934 in Great Britain; bricks of a 75-25 mixture of dolomite and "Sudanite rock" gave encouraging results in openhearth furnaces. However, they hydrated in storage and "dusted" in the furnace. Further tests indicated that calcined dolomite could be stabilized by firing it in a rotary kiln with a suitable admixture of serpentine. Bricks made from such

clinker do not contain free lime and do not "dust". They compare favorably in properties with magnesite bricks, but they have a lower resistance to thermal shock and to corrosive slags high in iron oxide.

They have been used with complete success in the tap-holes, hearths and banks of fixed openhearth furnaces and in the banks and top layers of the sub-hearths of tilting furnaces. They have also given good service in reheating furnaces at temperatures of heavy scale formation.

Dead-burned magnesite in a stabilized dolomite brick increases the thermal shock resistance, sometimes to a spalling resistance index of 30 reversals. These bricks have had a limited success in exposed positions.

Semi-stable dolomite bricks have a low porosity, good crushing strength, a high refractoriness-under-load and good thermal shock resistance. Their resistance to slags high in iron oxide and lime is greater than ordinary stabilized dolomite brick. However, they can be stored for only a limited period.

The tendency of dolomite-chrome bricks to soften at working temperatures has prevented their commercial application.

Magnesite-dolomite bricks have a low porosity, a high refractoriness-under-load, an unusually high thermal shock resistance, and a slag resistance only slightly inferior to that of magnesite itself. 80-20 magnesite-dolomite bricks have given encouraging results in tilting-furnace back walls.

Dolomite bricks in which the lime is protected from hydration by a coating of flux have an equal life, and a higher thermal shock and slag resistance than chrome-magnesite bricks in fixed openhearth furnace back walls. Ⓔ

*Abstract of "Dolomite Bricks for Use in Steel Works", by T. Swinden and J. H. Chesters, Advance Paper for British Iron and Steel Institute, August 1941.

DURALOY

HIGH ALLOY CASTINGS

CHROME IRON ★ CHROME NICKEL ★ NICKEL CHROME



Backed by twenty years' experience confined solely to the production of high alloy castings.

This is your assurance of getting a sound casting to take care of that condition of high temperature, corrosion or abrasion . . . for experience is the most important factor in the production of the so-called high alloys.

Write us in detail about your problem. Our metallurgists will be glad to recommend the proper analysis and will advise whether or not a centrifugal casting, which is distinctly better than static castings, can be used.

THE DURALOY COMPANY

Office and Plant: Scottsdale, Pa.

Eastern Office: 12 East 41st St., New York, N. Y.

Detroit
The Duraloy Co.
of Detroit

Scranton, Pa.
Coffin & Smith

Los Angeles
Great Western Steel
Company

Metal Goods Corp.: St. Louis—Houston—Dallas—Tulsa—New Orleans

4-DU-2

Sier Bath GEARS



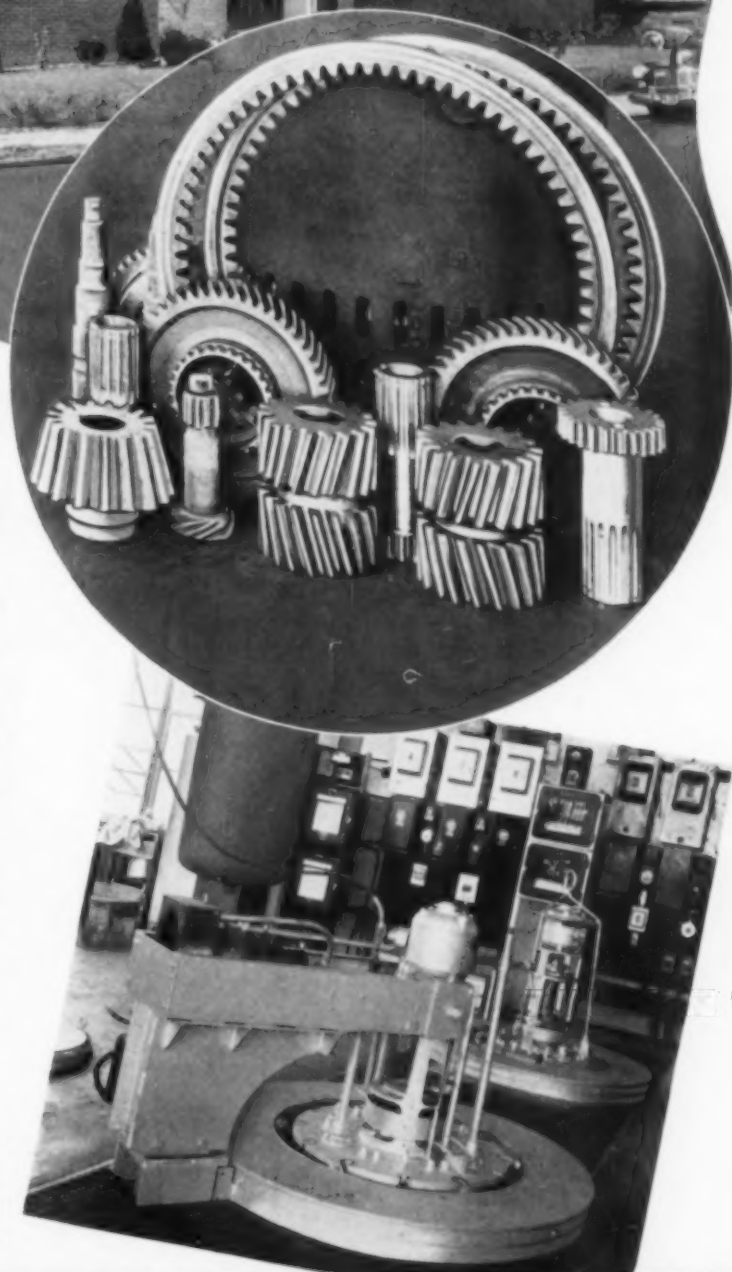
HEVI DUTY FURNACES

Top quality for Sier Bath "Tailor Made Gears" is assured through uniform heat treatment. Sier Bath gears are carburized in Hevi Duty Vertical Retort Electric Furnaces having multiple zones of heat control—a guarantee of uniform and precision carburizing.

Send for Bulletin HD-142.

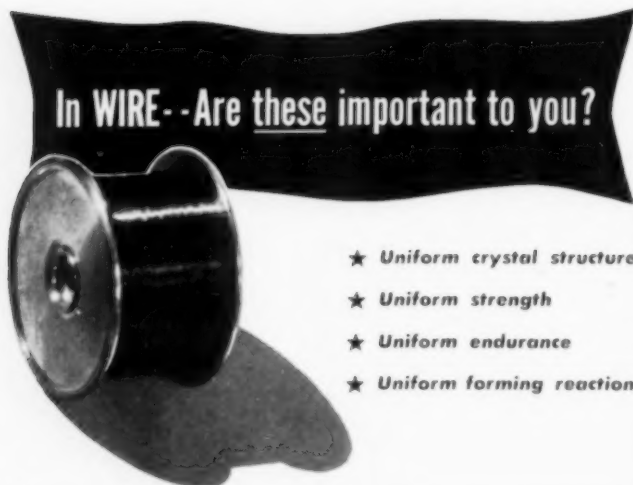
Above—The new Sier Bath Plant at North Bergen, N. J.

Below—Two HD-1824 Vertical Retort Furnaces at Sier Bath.



HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES **HEVI DUTY** ELECTRIC EXCLUSIVELY
MILWAUKEE, WISCONSIN



In WIRE--Are these important to you?

- ★ Uniform crystal structure
- ★ Uniform strength
- ★ Uniform endurance
- ★ Uniform forming reaction

Callite's precision-and-quality control of drawing and treating processes guarantees dependable uniformity of composition, temper, tolerance and finish... in fine wires for every need... in sizes down to .002" (smaller if required.) If challenged by unfamiliar wire problems, let our technicians give you the benefit of Callite's great backlog of metallurgical research. Save precious time, call Callite today! Callite Tungsten Corporation, 557-39th Street, Union City, New Jersey. Branches: Chicago, Cleveland, Cable, Callites.

Callite Wires

A FINE WIRE FOR EVERY NEED

**CALLITE
FINE WIRES**
for every need

BERYLLIUM-COPPER
PHOSPHOR-BRONZE
ALUMINUM
SILVER
STAINLESS STEEL
MOLYBDENUM
MONEL
NICKEL-SILVER ALLOYS
BRUSH WIRE
TUNGSTEN
COMMERCIAL BRONZES
BRASS - ALL GRADES
SILICON BRONZE
SPECIAL ALLOYS



Iron Powder

(Cont. from p. 540) fines above about 30% seriously affects the cold-pressing quality of the powder. Admixture of electrolytic powder, all finer than 25 microns, up to about 10% to the mixture of 66% coarse, 17% medium and 17% fine, or the use of a 17% coarse, 66% medium and 17% fine mix does not appreciably alter conditions. Within limits many different size distributions are adequate for pressing sharp angled compacts but, unless lubricants are employed, ease of pressing to shape and automatic ejection are more difficult the higher the percentage of extreme fines.

Micrographic studies of compacts of electrolytic iron, sintered at 1515° F., show that all are completely recrystallized and the grain size has been affected by the initial size of the powder used. When heat treated for 4 hr. at 1560 to 1650° F., the temperature region of excessive grain growth, all four structures are alike in that the grain size is extremely large, as in Fig. 5 f. In this temperature range large grains are first apparent (after 30 min.) in the compacts of mixed particle sizes.

Post Working — A comparison of the physical properties obtained with fusion products and with powders of the kind here described, leaves much to be desired in regard to the latter. Some improvement is to be expected for higher sintering temperatures and some for cold re-pressed and annealed materials; properties equivalent to those of fusion products are only obtained after hot working or hot pressing.

Electrolytic powder of the mixed particle size already described was cold pressed at 33 tons per sq.in. into bars $6 \times \frac{1}{2} \times \frac{1}{2}$ in. and sintered 4 hr. in dry hydrogen at 2200° F. One set of samples was reduced hot in a forging die with a 300-lb. motor-driven hammer immediately after removal from the furnace. Another set of samples was cooled in hydrogen and re-pressed cold at 33 tons per sq.in. To achieve greater cold reductions than were possible with the available press, cold swaging of the bars was carried out. Cold reductions greater than 38% required an intermediate anneal. All specimens were annealed in hydrogen at 1830° F. for a half-hour and furnace cooled in 3 hr. from this temperature. The major part of the internal oxide acquired in hot forging was subsequently reduced in the final anneal. From the test results it becomes evident that the density and percentage elongation of the hot-worked samples are appreciably better than the cold-worked. 7.5% reduction of hot metal is more effective than a cold reduction of 31.5%. The former gives 36,600 psi. tensile strength, 34.5% elongation and 7.78 g./cc. density; the latter 35,450, 24.4 and 7.68 respectively.

a complete stock of standardized

INDUSTRIAL THERMOCOUPLES

and their accessories
for all makes of pyrometers

— ❧ —

THERMOCOUPLES LEAD WIRE
THERMOCOUPLE WIRES
INSULATORS TERMINAL HEADS
CONNECTORS
PROTECTION TUBES

— ❧ —

ARKLAY S. RICHARDS CO., INC.

72 Winchester St. Newton Highlands, Mass.

STEEL CASTINGS

FOR THE BIG GUNS



RIGIDITY,
IMPACT RESISTANCE,
PERFORMANCE, PRECISION

Did you ever see...

a gun big enough and powerful enough to throw a projectile weighing as much as a Ford sedan a distance of 30 miles?

That is the kind of guns we are building for coast defense. Gun, carriage and mechanism weigh as much as three-quarters of a million pounds.

It is certainly logical that they should build the supports for such heavy ordnance of steel castings.

Steel castings are rigid and strong enough to support tremendous weights, and to withstand tremendous shocks and impacts. They permit accurate assembly and precision adjustment. And they can be made and assembled quickly—a vital consideration in our race against time.

Whether the essential parts of your product are weighed in ounces or tons, chances are you can save time and money, and turn out a better product, if you also use more steel castings.

To learn more about this thoroughly practical way to secure all of the unquestioned advantages of steel as a material, consult your local foundryman, or write to Steel Founders' Society, 920 Midland Bldg., Cleveland. You incur no obligation by asking for information.

STEEL CASTINGS BRING YOU THESE 7 ADVANTAGES

- 1 *Uniform structure* for strength and shock resistance.
- 2 *Metal distributed* for strength with minimum weight.
- 3 *Wide range of mechanical properties.*
- 4 *Good machining qualities*—lower finishing costs, better appearance.
- 5 *High rigidity*, accurate alignment, minimum deflection, better fit.
- 6 *Readily weldable* in composite structures.
- 7 *High fatigue resistance*, longer life, ideal for critically stressed parts.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

Strategic and Critical Materials

(as of March 12, 1942)

WAR PRODUCTION BOARD has issued a "provisional report on the relative scarcity of certain materials". HARVEY A. ANDERSON, chief of the Conservation and Substitution Branch of the Bureau of Industrial Conservation, emphasized that the

status of *all* materials is constantly changing.

GROUP I is made up of materials that are critically essential for the prosecution of the war. For these materials civilian industry must largely find substitutions. Metals included are: Alloy steel including iron alloys and wrought iron, aluminum,

aluminum scrap, cadmium, calcium-silicon, chromium, cobalt, copper, copper scrap, iridium, lead, magnesium, nickel, tin, tinplate and terneplate, tungsten (high speed tools), vanadium. Other items used by ASMembers: Chlorinated hydrocarbon solvents, long fiber asbestos, Madagascar graphite, and tung oil.

GROUP II contains materials which are also necessary for war production and essential industrial activity, but the supply is not as tight. Necessary civilian industry may obtain limited supplies from this group to replace unavailable materials, when specific cases are considered to be sufficiently important. Metals included are antimony, arsenic, beryllium-copper alloys, calcium, manganese, mercury, molybdenum,* platinum, rhodium, carbon steel, steel scrap, zinc (all grades). Miscellaneous non-metallic items include anhydrous ammonia, barium carbonate, borax, carbon tetrachloride, cryolite, diamond dies, natural gas and palm oil.

GROUP III lists materials that are more available for substitutions, although in no case can the supply be considered unlimited, since other factors than the material itself may determine the amount available. Restrictions are commonly imposed, but supplies are not critically short, except in the case of iron and steel. The following are some items classed by Mr. ANDERSON as "substitute materials": Common asbestos, firebrick, coal and coke, gold, iridium, salt, silver. "Materials available in varying amounts for substitutions" include bismuth, palladium, petroleum oil, ruthenium, silicon and its alloys, uranium. "War materials presently [now?] available for substitutions in critical civilian industry" are basic low carbon steel, bessemer steel, gray cast iron, and malleable iron. ☉

*Placed under complete allocation "because demand has overtaken supply" on March 18.



ABILITY

Under the Hat

is What Counts!

R-S Furnaces are "tailor-made" for the particular heat-treatment of a particular product in a particular plant. This calls for engineering ability of high calibre—ability to pool experience and take advantage of local conditions for quick, quantity and quality production.

For resourcefulness, inventiveness and downright engineering skill, R-S Engineers are equal to the best. Add to this the foresight of preparation for quick delivery and you can do no better than to invest in an R-S Furnace, regardless of your product or heat-treating requirements.

Write or wire for detailed information.

R-S PRODUCTS CORPORATION
110 Berkley Street
Philadelphia, Pa.



R-S FURNACES OF DISTINCTION

GA ALLOYS

THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION

X-ite

W.P.B. Restrictions on Nickel & Chromium;—"Ersatz Alloys"

On April First, the War Production Board called a meeting in Cleveland of Furnace Manufacturers, Oil Mill Builders, and Alloy Manufacturers. The meeting was for the purpose of conserving Nickel and Chromium, demand for which in our VICTORY Program greatly exceeds our supply.

The meeting was called and presided over by Dr. George Waterhouse, Executive Consultant of the Iron and Steel Section of the W.P.B. Dean Bradley Stough, Head of the Heat Treating Equipment, representatives of Army Ordnance Department, Office of Administration, and other Government Agencies were present. No users were represented. Under ordinary conditions there are several users who buy more alloy than the largest Furnace Builders, and hundreds of them who buy more than many of the smaller Furnace Builders.

ALLOY furnace parts are only a fraction of the parts in most heat-treats. Normally the bulk of all heat-treat parts are replacements, and misc. alloy trays, tools, containers, etc., comprising about 90% of the alloy used in Heat-Treats, is bought direct. We assume that the W.P.B. will make an effort to look at the user's viewpoint and experience.

The user has been keeping score on his own alloy and has a far better detailed picture than the Furnace Builder who has only been giving one year guarantees backed up by the Alloy Mfr., and some cases than the Alloy Mfr. who lives with the services alloy in the field. The user has the only PICTURE OF THE EXACT CONSEQUENCES OF REDUCED ALLOY LIFE, REDUCED SAFETY FACTORS, MORE FREQUENT BREAKDOWNS in his own applications.

The Cleveland meeting was well attended. All present attacked the problem with patriotic zeal. The Furnace Builders stated that price of alloy was a secondary consequence, and the Alloy Mfrs. expressed their willingness to make anything that would help to VICTORY. The Government is undoubtedly going to make a very fair, intelligent evaluation of the relative importance of different applications of Nickel & Chromium to VICTORY and Dr. Waterhouse and his associates are eminently qualified to conduct the very thorough investigation necessary to proper evaluation.

ANEST THUM, Editor of Metal Progress, has in this issue covered the Cleveland Meetings of Apr. 1st and 4th, and gives you the outline of the recommendations of the Furnace Builders and Alloy Mfrs.

REMEMBER that these were of necessity hastily arrived at and are a compromise of the Engineering and Metallurgical Judgment of these groups with the necessity for Nickel & Chrome conservation. Some of these compromises are on microscopically small scale, and will, if written into an order by W.P.B., cause plenty of hell with Heat Treating operations by injecting alloys of proven inferiority into production lines, and projecting prematurely promising alloy experiments from the lab to the line.

A LOT of people agreed on 6% chrome as a compromise in low temperature ranges up to 1400° F., and further consideration brought out the facts that

this alloy is unproven above 1100° F., and limited below. Nobody could support any alloy below 24Cr-12Ni for intermittent heating at any red temperature suitable for general application, and a large majority of the broadly experienced individuals in each group have small enthusiasm for general application of "24-12" in intermittent heating operations, although there are a number of such successful operations, and the variations of this alloy of which General Alloys makes considerable tonnage, hold definite promise.

THERE is some research work on the "24-12" type alloys recently done by Battelle Memorial Institute for the Alloy Casting Institute, (of which G.A.Co. is a Charter Member), which has had some rather wide ballyhoo. We consider this a competent research job, as far as it has gone, but it largely duplicates work done years ago by the Electro-Metallurgical Corporation, and others, being more remote from the practical considerations of service conditions and foundry practice. New specifications drawn around this research, while they can be met by a number of competent producers under controlled conditions, are definitely "tricky", require grades of raw materials not freely or dependably available, and are of chief interest to the Petroleum Industry and their suppliers.

THE Alloy Casting Institute is expanding its Research Program, to aid in Nickel & Chromium conservation and aid to VICTORY through betterment of alloys. We are fully supporting that program, and doing more extensive research on a General Alloys program in co-operation with users and directed at quick practical application of all available technical knowledge not employed in practice.

THERE are a lot of "Development" and "Research" eggs in various incubators, a lot of which are minus rooster, if not hen. Wishful thinking and metallurgical hybridizing will produce a plethora, if not a diarrhea, of "heat resisting cast irons," and Caveat Emptor Ersatzalloys, many of which have sprung from a gleam in a salesman's eye born on April Fool's day.

IT is not our purpose to belittle Ersatz, we may be using a lot of Ersatz in many lines before we whip the Nazisobs, Japsobs, Wopsobs, and all the little Axisobs,—but let's not kid ourselves about it. The Ferro-manureum content should be on the label.

EVERYONE would like a good nickel cigar or a good ten-cent golf ball. There are few Purchasing Agents who have made a practice of buying alloys of richer alloy content, and higher price, than they believe they need. We've passed through a depression in which everything was pretty well chiseled down to a standardized mediocrity. There are exceptions where better than necessary alloys are used, but less, we believe, than cases where the more severe demands of VICTORY Production have necessitated increase in alloy quality.

ASSUMPTION that we can make very appreciable economy in Nickel use by metallurgical sub-substitution without costly interruption to production, or greatly increased inventories is, we believe, less promising than the obvious possibilities of Nickel &

Chromium saving through reduction of alloy sections, and weights through engineering, by the use of several alloys to meet varying conditions in the same furnace, by arming Ersatzalloys with proven materials, by generally applying the lightest and most efficient alloy designs that have been proven in service.

THE saving of Nickel & Chromium is not an end in itself. The UTMOST UTILIZATION of the Nickel & Chromium available to our VICTORY effort is OUR COMMON END. The Alloy Casting Industry consumes only 6% of our total nickel. We submit that very little of the remaining 94% is as vital to VICTORY, and cannot be Ersatzed with less hazard to VICTORY PRODUCTION.

WE point out that it is not uncommon for ONE POUND OF Ni-Cr ALLOY TO CARRY ITS OWN WEIGHT IN ORDINANCE MATERIAL EVERY ONE TO TEN HOURS. There are many installations where two thousand pounds of alloy rails carry twenty-five tons of load through a furnace per day for years. The failure of a one pound alloy link in many furnaces would cause a breakdown costing the loss of five to fifty tons of material treated. A fifty man heat treat often handles the production of a thousand machine operators through a few furnaces.

THE shortage of Nickel & Chromium may become so acute, that we stop using it in portholes for Corvettes, stop shooting it at the enemy in shells, and can afford, as a Nation, to trade PRODUCTION INTERRUPTIONS FOR NICKEL.

OUR Government, in its wisdom, must make the decision on Nickel & Chromium allocation. We feel confident that it will make a careful evaluation, and the best possible choice. GENERAL ALLOYS WILL CHEERFULLY, WHOLEHEARTEDLY COOPERATE IN ANY DECISION RENDERED, AND WILL USE OUR UNEQUALLED ENGINEERING AND METALLURGICAL EXPERIENCE AND FACILITIES INCLUDING PATENTS & PROCESSES IN THE COMMON GOOD.

GENERAL Alloys have the most complete melting facilities in the industry, including Direct Arc Melting, 3 Phase Indirect Arc Melting, and latest Hi-Frequency Induction Melting, and has the technically trained organization to meet any specification suggested on any alloys, Ersatz or otherwise.

THOSE users who have chosen their alloy supplier on the basis of past technical achievement have grounds to expect sound guidance in the troublesome times ahead.

Watch this page for new developments in HEAT & CORROSION RESISTANT ALLOYS.

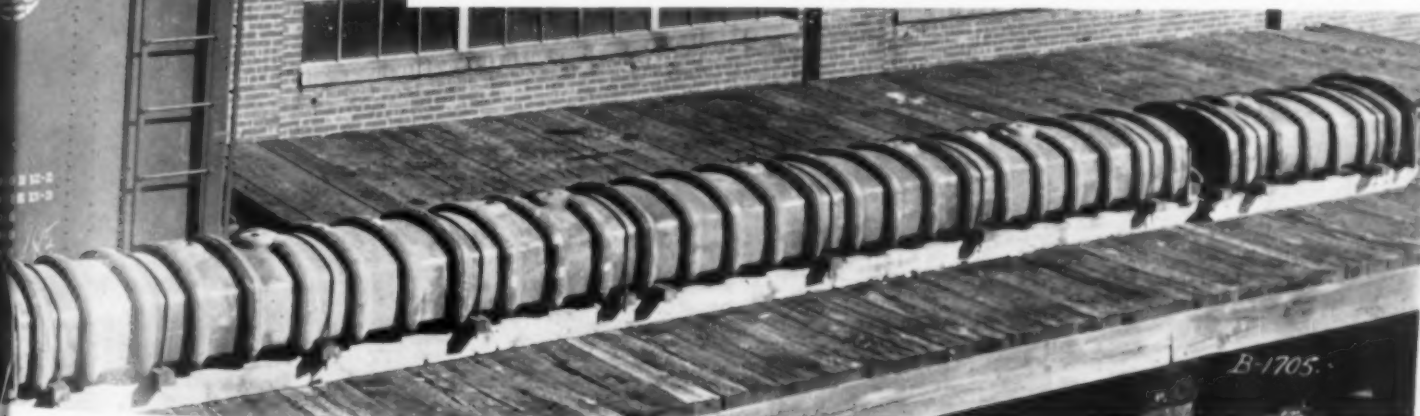
Robert Harris

This is an advertisement of General Alloys Company, Oldest and Largest Exclusive Manufacturer of Heat & Corrosion Resistant Alloys. Main Office 367-405 W. First Street, Boston, U.S.A.



Best Way to Save Alloy is Through Engineering

This "Equi-Flex" X-ite Muffle is one of several supplied the Allis-Chalmers Company for use in their SURFACE COMBUSTION GAS CARBURIZERS. Similar designs have been supplied for HOLCROFT GAS CARBURIZERS.



B-1705

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

GA X-ITE

GA ALLOYS

GA X-ITE

Foundrymen

(Continued from page 527)
the pattern is constructed. Sometimes the designs can be modified without harm to the functioning of the part, yet with great help to the foundry.

"ArmaSteel" was described by CARL F. JOSEPH, chief metallurgist of Saginaw Malleable Iron

Division of General Motors Corp. This is a heat treated malleable iron (or "arrested malleableized steel") made from white iron castings containing about 2.65% C, 1.30% Si, 0.40% Mn, 0.13% S and 0.05% P, cupola melted, and transferred to electric furnace for close control of chemistry, and for superheating. After malleableizing about 15 hr. at 1750° F., the parts are oil or air quenched from 1600° F. and

drawn appropriately for required physical properties (1250° F. for 6 hr. would be typical). Atmosphere control in the heat treating furnace prevents surface decarburization — a process that is now relatively common in the malleable industry. (Other pearlitic malleables are also being made, although often with higher manganese — for instance, "Gen-Steel" of General Malleable Corp. analyzes more nearly 0.80% manganese.) Mr. JOSEPH stated that ArmaSteel is 10 to 30% more machinable than carbon steel forgings of the same Brinell hardness. Anything that improves machinability these days is worth attention. [I have no doubt that the greater demands made on forge shops and steel foundries will open up a lot of opportunities for cast irons, malleable irons and modifications thereof, and I am sure that many of these, when established, will hold beyond the shortage that initiated them.] W. D. MACMILLAN of McCormick Works, International Harvester Co., reported some work on annealing times as related to Si and Mn content. 0.38% Mn was reported as annealing successfully. He also mentioned producing white heart malleable by annealing in an atmosphere of carbon dioxide.

Heat treatment of iron and steel castings is probably an old story to those who have made serious efforts to improve the quality of the foundryman's product. Considerable possibilities lie in the matter of "controlled directional solidification". Possibly this is nothing new to the centrifugal casting, or even the chill casting. One of my former students tells me of practices on alloy iron crankshafts. The molds are of dry sand, clamped between plates and balanced on a trunnion. They are poured horizontally and immediately turned vertically, with the riser up, giving greater pressure and feed.



Pulley Hub

IT'S MADE OUT OF
SPEED CASE STEEL
A LOW CARBON OPEN HEARTH PRODUCT

—because . . .

- It increased production 67%!
- It saved \$60.08 per ton of steel used
- It riveted without fracture
- It increased tool life 25%

In this "all-out" war effort Monarch Steel is co-operating 100%.
We're helping to "keep 'em rolling" with Speed Case Steel.



Ductility
Plus
Machinability
(230 SFPM)

Licensed for Eastern States
THE FITZSIMONS COMPANY
YOUNGSTOWN, OHIO

Licensed
MONARCH STEEL COMPANY
HAMMOND • INDIANAPOLIS • CHICAGO
PECKOVER'S LTD., Toronto, Canadian Distributor

MANUFACTURERS OF COLD FINISHED CARBON AND ALLOY STEEL BARS

QUENCH



*A revolutionary new
dual-action quenching oil*

field—on many types of steels, and on various shapes. In many instances, quenching with this new medium has resulted in a marked improvement in physical properties.

Gulf engineers are at your service to consult with you on your quenching problems. For further information, write today to Gulf Oil Corporation, 3800 Gulf Building, Pittsburgh, Pa.

*Mail This
coupon Today!*



Gulf Oil Corporation · Gulf Refining Company
3800 Gulf Building, Pittsburgh, Pa.

MP

Please send me, without obligation, complete information on Super-Quench, your new dual-action quenching oil.

Name

Company

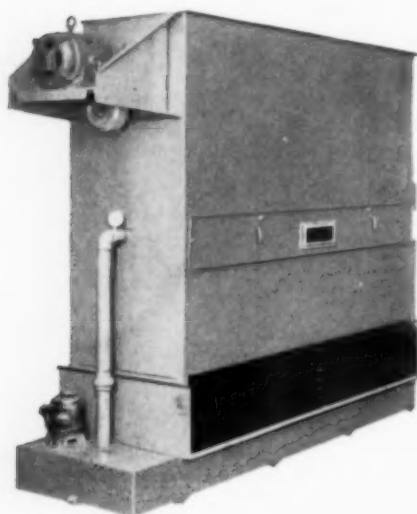
Address

April, 1942; Page 567

New Products Available

Liquid Heat Exchanger

Successful installations have been made in wire mills, heat treatment departments and chemical processes of new evaporative type unit for removing heat from various industrial lubricants and quenching baths. Unit consists



of a casing containing tubes through which the hot liquid passes. Sprays drench the tubes constantly with water, and air is drawn through the casing by a fan, applying the principle of evaporative cooling. Only the water evaporated is consumed, saving 95% of the water ordinarily used with shell-and-tube heat exchangers, it is said. Provision is also made for a heating coil in the receiving tank, for reheating the cooled solutions as required for controlled temperature quenching baths. (No. 30)

New Cement

New cement for laying insulating firebrick is particularly suitable when directly exposed to furnace temperatures over 1800° F. Because a "fired bond" is not attained at lower temperatures, back-up brick which are laid with this cement can readily be salvaged. Cement is said to provide improved workability, greater

coverage, a high degree of bonding strength. (No. 31)

Cleaner for Light Metals

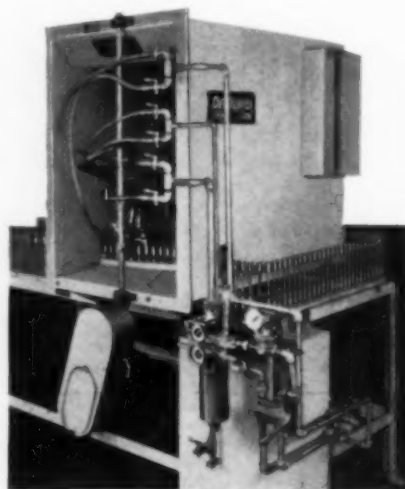
"Mattawan Al" is a cleaner for aluminum and magnesium sheets and castings. Used at a concentration of 4 oz. per gal. at 160° F., it does not etch nor corrode aluminum sheet or castings even after 2 hr. immersion. Machined and polished magnesium shows no weight loss or etching in 15 min. Specially suitable for aircraft parts. (No. 32)

Cutting Oil

Sulphurized cutting oil for high carbon steels is said to have special properties which speed all machining of hard steels. Large sulphur content is responsible for cooler and faster cutting, it is claimed. This oil is transparent, enabling the machinist to see the cutting edge constantly—a highly important factor in precision work. (No. 33)

Painting Small Shell

Recent development in painting equipment is a standardized automatic machine for small shell parts, shot, and fuses. Machine coats exterior of 20-mm. shell at rate of 2000 per hr., and is built around a "chain-on-edge", vari-



able speed conveyor of sufficient length to allow for 10 min. for drying at a production rate of 1000 per hr. Spray guns are the automatic air-piston type with adjustable spray control. (No. 34)

Forge Welder

Designed for resistance welding of heavy sections and of special alloy steels, such as homogeneous and face-hardened armor plate, and for shipbuilding, new "Temp-A-Trol" forge welder both spot welds and heat treats the weld. Close control of size and ductility of weld nugget, and its grain refinement, are thus obtained. Also said to avoid annealing of hardened surfaces of the plates. Temperature at the weld itself automatically controls the current and operating cycle, self-compensating for such variations as normal difference in metal thickness, induction and short-circuiting losses, and presence of scale. Detailed information furnished only to organizations engaged in or contracted to engage in war production work. (No. 35)

Surface Measurement

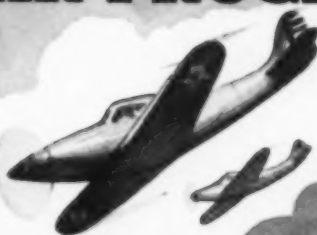
Profilometers (instruments for the measurement of surface roughness and providing direct dial readings in true inch units) are now available with a new accessory unit adapting them for use with 115-volt, 50 to 60 cycle, a.c. circuits. (No. 36)

Wetting Agent

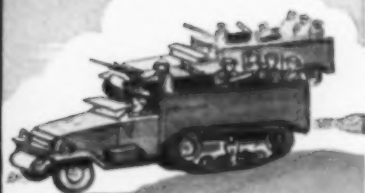
Improved wetting and emulsifying agent, "Dresinate", for use with all types of alkaline metal cleaners is said to assist these solutions—and in certain applications to replace some of the chlorinated solvents, now scarce. The penetrant, a finely divided, uniform powder, is available in (Continued on page 570)

We will gladly pass on to the manufacturers requests for further information on products described here and on Page 570. Mention the paragraph numbers of the items in which you are interested

National's PART IN AMERICA'S WAR PROGRAM



In every branch of Uncle Sam's Armed Forces you will find National Quality Sand and Permanent Mold Aluminum Castings. Because of our long experience in making quality products, we were selected to produce castings for every branch of Uncle Sam's Armed Forces...A good thing to remember when normal times arrive.



Make
NATIONAL Your Source of Supply
FOR SAND AND PERMANENT MOLD
ALUMINUM CASTINGS

National
CASTINGS
ARE BEING WIDELY
USED TO SPEED
VICTORY

THE NATIONAL BRONZE AND ALUMINUM FOUNDRY CO.

Twin Plants, Cleveland, Ohio

NEW YORK, 111 Broadway
DETROIT, Stephenson Bldg.

CHICAGO, 188 W. Randolph
LOS ANGELES, 405 S. Hill

New Products

(Continued from page 568)

practically unlimited quantities at a lower cost than the common emulsifying agents used by the metal cleaning industry. (No. 37)

New Welding Rod

Manganese steel welding rod known as "V-Mang" conserves nickel by using 12 to 14% manganese, plus a little molybdenum

and other elements. Can be applied as readily as nickel-manganese steel rod and has at least equal ductility and tensile strength. (No. 39)

Drawing Furnace

Said to speed the tempering of tools, dies, small parts, and non-ferrous castings—in fact for any work requiring the temperature range from 275 to 1200° F. Designed as a production furnace and known as the "820", it is

compact, heavily lined with insulating refractory, and equipped with two large atmospheric burners. Firebox size is 16 by 16 by 14 in. (No. 40)

Motor Blower Units

Available in 16 models; applicable to industrial and commercial ventilating, drying, heating, cooling, and other uses. Units are produced in one, two and three-fan assemblies to meet resistance up to 4-in. pressure, and in capacity from 880 to 42,600 cu.ft. per min. Fan speeds range from 300 to 1750 r.p.m. Blowers may be secured with or without casings. (No. 41)

Cleaner for Welds

Power-driven end brush, designed particularly to clean slag or scale from welds on inside corners, as well as other locations difficult of access. Brush will get into any space which is accessible for welding. (No. 42)

Anti-Rust Oil

"Miccroil" is a new anti-rust oil with high flash point and fast drying time (30 to 45 min.). Light in color and transparent, it does not change the appearance of the part on which it is applied. Exposure tests of coated steel panels show no appreciable change at the end of a month in a typical plating plant. No deterioration was shown after 48 hr. in a continuous spray of 20% salt solution. Aircraft parts, gages, precision tools, other machined or polished parts, and stampings can be protected. (No. 43)

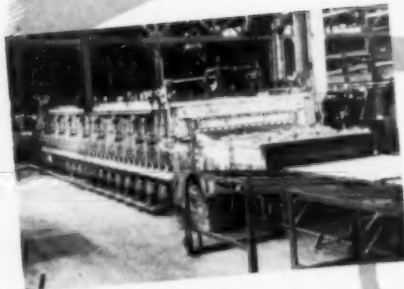
Sequence Timer

Weld and sequence timer, developed for automatic resistance spot, butt or projection welding. Timer divides the total time of a weld into the various intervals in which the welder goes through its operating sequence and includes a "weld" period of 3 to 30 cycles when the full welding current flows. When welding thick plates, brass, or stainless steel, timing facilities permit intermittent heating and cooling steps of from 3 to 30 cycles. (No. 44)

FURNACES THAT SAY IT WITH PRODUCTION

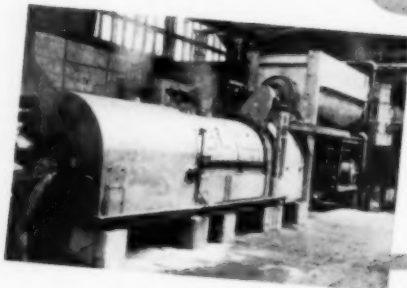
In the heat treatment of shells and other defense products, Rockwell Furnaces speak for themselves. Here are several of the many types that say it—convincingly—in terms of production.

18,000 LBS. PER HOUR



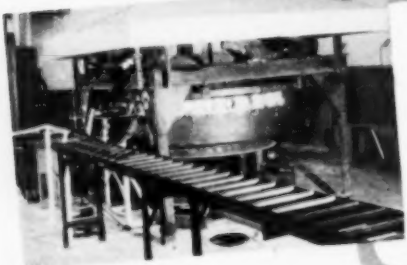
This Gas Fired Roller Hearth Annealing Furnace handles cartridge brass slabs. Construction is unusually rugged—the rolls are extremely heavy, and the drive and all other parts are capable of this extreme production rate. Driven rolls carry the slabs from the charging table through preheating, heating and cooling sections, and on the discharge table to the dump mechanism.

3,000 LBS. PER HOUR



A Gas Fired Revolving Annealing Furnace (Retort Type) that is a complete unit for washing, annealing and pickling 50 caliber brass cartridge cups in a continuous, even stream. A great producer, it is also exceptionally economical from the standpoint of labor, fuel and in the use of acid.

70 SHELLS (4.5") PER HOUR



A Revolving Hearth Type Shell Nosing Furnace with openings around its outside circumference for receiving the shells. Heating is so controlled that no distortion occurs below the taper during the press operation. Charging and discharging from the same position requires only one operator—shells being sent to him on a conveyor. The absence of a water-cooled chill results in a great saving of fuel.

Because of standards already established, time-saving deliveries can be made on many types of Rockwell Furnaces that will step up your production. What is your heat treating problem?



W. S. ROCKWELL CO.

50 CHURCH STREET

NEW YORK, N. Y.

WHAT IS A SUPER-CYCLONE FURNACE?

It is a further development of the Lindberg Cyclone furnace utilizing 100% forced convection heating with temperatures to 1750° F.

HOW WILL THE SUPER-CYCLONE HELP ME?

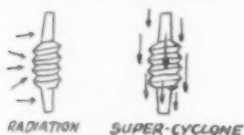
It all depends on the type of work to be done. Among the operations being handled by well over 100 Super-Cyclone installations already in service are: tempering, annealing, hardening, normalizing, and nitriding. Because the work can be preheated at any desired rate and cooled according to a definite schedule, the Super-Cyclone is well suited to stress relieving, spheroidizing, malleablizing, and other special heating operations requiring a definite cycle.

CAN THE SUPER-CYCLONE BE USED FOR LOW TEMPERATURES?

Yes. The temperature range of the Super-Cyclone is 250° F. to 1750° F. with equal heating and control accuracy within the range. This feature of the Super-Cyclone gives you a tempering, hardening, annealing, and normalizing furnace all in one and makes it a flexible unit for the small or medium heat treating department, as well as a heavy production unit for the large shop when put to work on one type of job.

HOW DOES THE SUPER-CYCLONE KEEP WORK STRAIGHT?

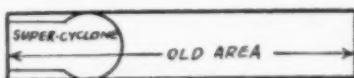
By eliminating "one-sided" heat. The work is piled up or stacked up in the work chamber, either on itself or on a fixture, and the heat is driven through it at a high velocity, heating each part thoroughly and accurately. The 100% forced convection heating principle prevents radiant heat of a source hotter than the desired work temperature from striking the charge and causing distortion. This proved itself in handling 20 pound worm gears. When hardened from box furnaces 85% went out be-



come .015" to .025". Straightening took 8 hours per 100 worms. When hardened from the Super-Cyclone, 90% required no straightening whatsoever, and the

balance were out a maximum of .010". Straightening time: 30 minutes. A reduction of 7½ hours straightening time per 100 worms.

5. HOW ABOUT FLOOR SPACE?



As a general rule, based on what the Super-Cyclone has done in other plants, you can figure that this furnace will require only ½ the floor space of any other type of equipment to handle the same or increased production. At a large midwestern plant annealing grey iron castings, one Super-Cyclone using but 1/6 the floor area, replaced 8 radiation type box furnaces and turned out twice as much work! It would take 7 box furnaces and 7 men to approximate the production of the Super-Cyclone shown on the opposite page. Another manufacturer, hardening worm gears found that one Super-Cyclone did the work of 3 box type furnaces occupying 3 times the floor space.

6. HOW ARE PRODUCTION POSSIBILITIES FIGURED?



You can roughly check the production increases possible through the Super-Cyclone, by spreading parts to be heated on the floor, one layer thick, as laid out in a radiation heated furnace. Then take those same parts and stack them up in a 36" circle, 4' high, making allowance for spacers or supports. Figure it will take a maximum of 3 hours to heat the stacked up parts on a fixture and 5 minutes to quench the lot. Ordinarily you will find production increases of 200% to 1000% possible. The parts remain on the fixture for quenching and tempering, a substantial saving in handling.

7. DOES THE NAME SUPER-CYCLONE MEAN THAT IT IS A LARGE FURNACE?

No. A standard size Super-Cyclone is made with a chamber dimension as small as 16" diameter x 20" deep. The name Super-Cyclone denotes the ability of the furnace to increase production and keep work straighter by using 100% forced convection heating with temperatures from 250° F. to 1750° F.

The name "SUPER-CYCLONE," like Topsy, just grew. During its infancy on the drawing boards, the engineers planning its potentialities, called it the "Super" Cyclone. Then came its adolescence in the shop where the boys referred to it as the "Super." When troubles developed, the service men called it something else. But whether it was affection, anticipation, or just the lack of a better name, most everyone called it the "Super."

In the advertising department we got excited at the prospect of creating a name for the new product . . . a name that would go down through the ages with Buick, Bon Ami, Aunt Jemima, Carter's Little Liver Pills, and many others. We burned the midnight oil with creative fervor . . . "Little Demon Heat Treater" . . . "The Chinook" . . . "The Senator" (100% forced convection hot air) . . . "Breath of Sahara" . . . and other names, equally as inadequate, were conceived. Each new appellation was referred to as a name for the "Super" and before we knew it, we were calling it the "Super" too! When the time came to announce it to the trade, for want of a better name, we had to release it as the Super-Cyclone. We knew then, that we were but pawns in the hand of Fate. Our dream, of launching and christening this new furnace with a bottle of "7-up" and a few well chosen words, had blown up in our faces. We feared that in letting it be known as the "Super" Cyclone, the general opinion would be that our advertising department had "gone Hollywood."

Soon, reports on the new installations came in sounding like letters from Bob Ripley . . . and they continue to come. We know now, that this furnace by any other name would be as remarkable. The "Super" has clicked in the field! The advertising department still feels it owes an apology for the name "Super-Cyclone," but its performance is all that the name implies.

STANDARD SIZES IN WHICH THE SUPER-CYCLONE IS AVAILABLE

Delivery time is speeded considerably when standard size furnaces are selected, rather than special sizes which must be drawn up. Drawings are available for the following sizes of Super-Cyclones all of which have been built and are in operation. Most are gas fired, although a number are available electrically heated.

CHAMBER SIZE

16" diameter x 20" deep
22" diameter x 26" deep
22" diameter x 36" deep
25" diameter x 20" deep
25" diameter x 30" deep
25" diameter x 48" deep
28" diameter x 28" deep
28" diameter x 48" deep
28" diameter x 60" deep
33" diameter x 36" deep
33" diameter x 48" deep
38" diameter x 36" deep
38" diameter x 48" deep
38" diameter x 60" deep
43" diameter x 48" deep
48" diameter x 72" deep
60" diameter x 36" deep
60" diameter x 48" deep
60" diameter x 72" deep

100 SUPER-CYCLONE INSTALLATIONS ALREADY IN SERVICE

IMPORTANT NOTE: Like all other Lindberg developments, the Super-Cyclone has been thoroughly proved under 24-hour a day production conditions for a minimum of 12-months before announcement to the trade. Every effort has been made to restrict the sale of these units until the probationary period was completed. In spite of this, however, many of those who have seen the furnace in operation during the past 18-months have quickly been aware of its production possibilities and requested that units be constructed for them. Thus, over 100-Super-Cyclone installations are in service from coast to coast. One or more of these is near you, as is a Lindberg District Office, staffed by practical and competent sales engineers. The Super-Cyclone is not a cure all, nor do we represent it as such. It is speeding production, turning out straighter work, and cutting costs for many firms however, and we will be glad to survey its possibilities for you, on your work, at your request.

LINDBERG ENGINEERING CO • 2448 WEST HUBBARD ST • CHICAGO

FURNACES

HYDRIZING FOR SCALE-FREE AND DECARB-FREE HARDENING

Calcium Metal*

By A. B. Kinzel

CALCIUM has been thought of as a rare metal and has received comparatively little attention from industrial metallurgists. Its electrolytic deposition from a molten calcium

chloride bath was the first process to be used for commercial production, and is still the standard procedure. Production formerly was restricted to only a few plants in France and Germany.

Investigations at the Union Carbide and Carbon Research Laboratories resulted in several novel methods for making the metal, as well as much information pertinent to the standard electrolytic process, but no com-

mercial process was developed. However, in 1939 the Electro Metallurgical Co. decided to proceed with an industrial plant. To insure early production the standard electrolytic process was selected. Sault Ste. Marie, Mich., where an affiliated company owns a large power plant and calcium carbide works, was selected and calcium metal was being made regularly in the winter of 1939. Its present capacity is many times that of the previous demand, and the plant comprises many novel features.

The problem lies in the collection of the metal. Calcium reacts readily at elevated temperatures with practically all the elements except the noble gases. In addition, metallic "fog" forms in the molten electrolyte—perhaps even a subchloride exists. The need for extremely close control is emphasized by the fact that the melting point of calcium, about 1500° F., is only 70° above that of molten calcium chloride. Calcium deposits in the molten state, but is collected as a solid by continuous deposition and freezing on the cathode, the motion of which is adjusted so as to remove calcium from the bath exactly as fast as it is formed. The problem is further complicated by the generation of chlorine at the anode, and by increased bath temperatures due to electrode effects (polarization).

A radical change in cell design has brought about much larger cells than used heretofore, with a corresponding reduction in costs. The Sault Ste. Marie plant is satisfying the domestic demand at prices commensurate with those current during the past decade. Further, it has built up a working stock and can be expanded as required.

Calcium metal is available in a number of forms. The crude "carrot" produced in the cell is
(Continued on page 578)

*Extracts from *Mining and Metallurgy*, October 1941, p. 488.

USE **AEROCARB***...
FOR RAPID HARDENING,
EASY CLEANING IN
DEFENSE PRODUCTION



Courtesy of Indian Motorcycle Company

Economical AEROCARB carburizing materials produce rapid, uniform penetration in case depths from .002" to .030" in low carbon and medium alloy steels. Hardened parts are quickly and easily cleaned after an oil quench by washing in hot cleaning solution.

Uniform results in every heat are assured by using an AEROCARB A activator added at regular intervals to keep the molten bath in chemical balance. This constant balance, moreover, ends the waste and delays caused by "bailing out". Important, too, is the

fact that drag-out losses can be kept to a minimum because of the exceptional fluidity of the AEROCARB bath. No expensive special equipment is required... ordinary commercial pot furnaces can be used with the AEROCARB materials.

Write for full information on AEROCARB... AEROCASE*... and other carburizing and case hardening compounds made by Cyanamid. Cyanamid field engineers will be glad to consult with you to help solve your case hardening and heat treating problems.

*Reg. U. S. Pat. Off.

AMERICAN CYANAMID & CHEMICAL CORPORATION



A Unit of American Cyanamid Company

30 ROCKEFELLER PLAZA, NEW YORK, N. Y.

DISTRICT OFFICES: 89 Broad St., Boston, Mass.; 401 N. Broad St., Philadelphia, Pa.; Russell & Bayard Sts., Baltimore, Md.; 3333 Wilkinson Blvd., Charlotte, N. C.; 850 Leader Bldg., Cleveland, O.; 20 N. Wacker Drive, Chicago, Ill.; Miller Road, Kalamazoo, Mich.; 931 Fisher Bldg., Detroit, Mich.; 900 Shell Bldg., St. Louis, Mo.; Azusa, Calif.



SHELLS

DEMAND OILS made only for Quenching . . .

**FASTER, DEEPER,
MORE UNIFORM HARDNESS**

This is no time to experiment with so important an operation as quenching of armament parts. ★ Most men in the metal industry, respecting Houghton's half-century of experience extending over three wars, are choosing their quenching oil on the basis of our recommendation. ★ They realize that only an oil made solely for quenching will provide those qualities of quenching speed and uniform hardness, month in and month out. ★ For thousands of items involved in the war program they have come to depend on us for products and advice, both on heat treatment and metal working. And it's our pledge not to let them down. ★ When you face a metal treatment problem, call on us.

E. F. HOUGHTON & CO.

Chicago — PHILADELPHIA — Detroit

Houghton's
**QUENCHING
OILS**

Calcium Metal

(Continued from page 574)

the simplest and cheapest. Carrots are from 7 to 14 in. diameter and 7 to 25 in. long. Such metal is of high purity but contains entrapped calcium chloride, and the surface is covered with this salt. Carrots may be remelted and cast in molds, but all of the

oxygen and nitrogen-bearing gases must be excluded from the furnace. Special molds are required and pouring technique is an art in itself.


Two forms of cast slabs are produced, more or less as standard. One weighs approximately 50 lb. and measures about 2¼ by 16 by 25 in.; the other is much smaller—1 in. thick, 3 by 8 in area weighing approximately 1¼ lb. Turnings are likewise avail-

able. Cylinders are cast approximately 25 in. long and 7 in. in diameter with or without a center hole 2 in. in diameter. All cast calcium is commercially free from chloride. When an extremely high degree of purity is required, cast calcium may be distilled in high vacuum.

Calcium metal is used as a "deoxidizing", nucleation, or precipitation agent when added to non-ferrous metals; as a deoxidizer, sulphide former, and scavenger when added to ferrous metals; as a reducing agent for the preparation of the more difficultly reducible metals either directly or by the hydride route; and as an absorbent for oxygen, hydrogen, nitrogen, and other gases in chemical processes.

The use of calcium in the metallurgy of magnesium is most common. Additions up to 0.25% result in an improved surface on magnesium alloy castings; the metal retains a refined grain which shortens subsequent heat treating cycles.

Calcium has been used for deoxidizing aluminum castings, in refining secondary aluminum, and in maintaining lead in the emulsified state in leaded copper bearings. Hardened lead alloys, made with small additions of calcium metal to cable sheathing and to battery plates, may be of real economic and strategic value.

Calcium probably has specific effects in steel making in addition to those obtained from calcium when used in the form of a complex alloy containing other reactive metals. Ready combination with oxygen and nitrogen, the formation of a different type of sulphide, and a change in the nature of the non-metallic inclusions when calcium is added as a metal are most important and are the major reasons for its use. Today calcium, at its present base price of \$1.25 per lb., is less expensive than several metals in common industrial use. We may look forward to a stable domestic industry, and increased use. 



FORECAST:

*Some day, you'll look
up to this device*

BASIC in modern mill practice

This is the patented, exclusive Kemp Industrial Carburetor, the machine that provides *complete* premixing of gas and air to provide new savings, new heat liberation, new flexibility and new control in almost every type of ferrous and non ferrous heat processing.

As the basic unit in Kemp heat treating the Industrial Carburetor supports gas immersion melting in modern tin stacks, provides fuel for inert gas and for recirculating radiators in annealing covers, for Kemp Radiatube Roll Heaters, may be set for exactly the desired flame characteristics whether reducing, oxidizing or for complete combustion . . . and save 15 to 40 percent in fuel. For engineering details and assistance, address **The C. M. Kemp Manufacturing Company, 405 East Oliver Street, Baltimore, Maryland**

KEMP of BALTIMORE




FOR SELECTIVE NITRIDING

use Alkaline Tin Plating



SELECTIVE nitriding of steel parts for defense equipment doesn't have to be a problem if the right protective or stop-off agent is used. Tin plating, properly applied, gives excellent protection. The plated portions are unaffected by subsequent nitriding and retain their softness. Only a thin coating of tin is required but this surface must be uniform and dense, in order to get full protection.



For this type of work, the alkaline tin bath (Sodium Stannate-Acetate) has decided advantages over acid tin plating. The solutions are easily made up, controlled and operated. Throwing power is excellent. Thin and thick coatings with good adherence are readily obtained. The deposits are free from organic matter; nothing plates out which will carbonize at nitriding temperatures. The sodium stannate bath consistently produces smooth, fine-grained, uniformly distributed deposits of the required thickness, thus minimizing rejects. This is particularly important since expensive steels are employed and usually expensive preparation is required on pieces to be nitrided.

Further information about electroplating by the Sodium Stannate-Acetate process and treatment of steels can be obtained from our nearest district office.



E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
WILMINGTON, DELAWARE

Electroplating

(Continued from page 521)

amount of tin used by as much as 40% as compared to hot dipped coatings, and the resultant containers are safe for use in packing dry products and non-edible materials.


A direct use of tinplating in the Victory program, besides coating to resist corrosion, is in

the nitriding of steel parts. Whereas copper will prevent the passage of carbonaceous gases, it will not prevent ammonia from diffusing through, and depositing nitrogen in the surface layers of the steel. Tin, however, does just that, so parts to be partially nitrided are stopped-off with a tinplate. The plating bath for this purpose is usually an alkaline stannate; thickness deposited varies from 0.0002 to 0.0003

in. Excess thickness must be prevented, else difficulty may be encountered in the nitriding operation because of the low melting point of tin. (Nitriding is performed near 975° F. and tin melts at 450° F.; molten tin must not drip off onto bare steel parts, else a soft spot will result.) Since steel will pick up by diffusion about 0.0003 in. of tin before the tin even starts to run by capillary action to adjacent surfaces, it becomes possible to keep the nitriding operation within proper bounds by setting a maximum limit to the tin electrodeposit (0.0003 in.).

Zinc — Electro galvanizing is now in widespread use throughout our war industry. Methods used parallel those for electrolytic refining, a process commercial for 25 years, wherein zinc solutions are made from the ore. Electrodeposited zinc coatings on steel wire were described in METAL PROGRESS in May, 1937; continuous zinc coatings are now made on wide steel strip.

Zinc is plated on many small parts interchangeably with cadmium wherever good resistance to corrosion is desired. Many parts of the "jeeps" and other "rolling stock" for army locomotion are now zinc plated. A hundred and one appurtenances of both Army and Navy are now specified "to be zinc plated". Fortunately the available supply of zinc is more generous than of any of the other common metals, and so far no limitations have been placed on its use by the plating industry.

Conclusion — In this small space allotted we could not hope to mention, even, all the applications for plated metals and electrodeposited tarnish resistant finishes in our war effort, nor could we go into detail on them, for obvious reasons. However, some of the causes have been pointed out why the electroplating industry, almost flat on its back a few short months ago, is now alive and kicking. 

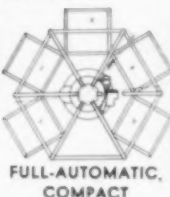


The Bullard-Dunn Process speeds up cleaning and descaling operations because it works rapidly and because it can be conveyorized. Scale-free and heavily scaled parts can be treated at the same time without damage to the former. Where work is to be electroplated, the scale or oxide removal and the plating can be done on the same conveyor. This eliminates unnecessary handling and times the operations to the minimum required, thus assuring a uniform and rapid flow of production. Bullard-Dunn has been used for years by many well known companies. One of the two largest manufacturers of airplane engines, for example, has eleven operating units.

Notice the features listed at the right. If your present cleaning and descaling method lacks even one of these features, write today for booklet giving complete information about the Bullard-Dunn Process.

THE BULLARD-DUNN PROCESS DIVISION
OF THE BULLARD COMPANY
BRIDGEPORT CONNECTICUT

BULLARD-DUNN
Process



FULL-AUTOMATIC,
COMPACT

CHECK THESE FEATURES

Rapid and economical
Easy to operate
No dimensional changes
No etching
Descals recesses
Produces chemically clean surfaces
Can be fully conveyorized
Long solution life
Rust protection of parts after descaling

LATROBE



MOLYBDENUM HIGH SPEED STEELS

DOUBLE-SIX
TATMO
TNW
HV-6
CO-6

For the tools of Victory

Latrobe's Molybdenum-Type High Speed Steels have been thoroughly perfected to meet today's varied and exacting cutting applications with increased toughness, improved efficiency and lower cost! • We can help you select the correct Molybdenum Type to best serve your particular requirements. Write.



Latrobe **ELECTRIC STEEL COMPANY**

MAIN OFFICES and PLANT ... LATROBE • PENNSYLVANIA

April, 1942; Page 581

Saving Chromium

(Continued from page 509)

charge contains 0.40 to 0.60% chromium. The slag volume must be kept low and the lime-silica ratio low (below 2.4). After rapid and thorough reduction, part of the slag should be skimmed a short time before final additions. The ferrochromium may be preheated more or

less according to the quantity to be added and the temperature of the bath determined when taking the spoon samples. If only a small quantity is needed or if the temperature is high, cold ferro may be added. Its quantity is adjusted according to the oxidation loss anticipated and according to the percentage of chromium expected to be reported for the last spoon sample on the basis of preceding

spoon samples and the course of the melting.

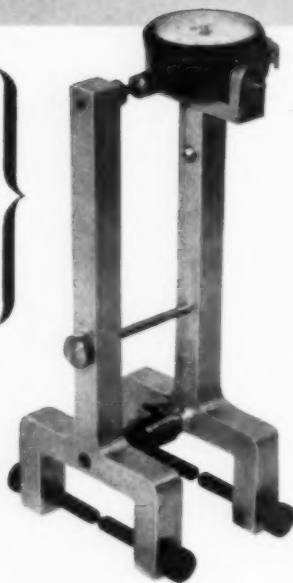
The statement that manganese and chromium acted in the same way during the refining stages, and that chromium was in fact easier to reduce from the slag than manganese, brought protests from some of the audience. One observed that in practical steel making the reduction of chromium offers far greater difficulty than manganese. Thus it is possible to obtain a satisfactory reversion of manganese from slag to metal with 2% of manganese on the charge since the slag is active, whereas with 2% of chromium on the charge adequate control of the heat is nearly impossible because of high viscosity of the slag.

Scientists from the National Institute for Iron Research confirmed both statements from an extended scientific study of the problem, as yet unpublished. W. OELSEN said that the difference between theory and practice was, in the main, a question of the melting temperatures of the slags, which increase with increasing chromium oxide content. That the recovery of chromium is considerably lower with increasing basicity of the slag is not so much due to the fact that chromium oxide is more stable in basic slag as to the fact that the slag becomes thicker the more basic it is. The influence of the lime-silica ratio is therefore due less to chemical than to physical causes. The basicity range of 1.6 to 2.4, in which the reduction of chromium is satisfactory, is obviously characteristic for slags of low viscosity.

F. KÖRBER also said it is considerably easier to reduce chromium than manganese in any slag; it is also easier to reduce chromium from acid than from basic slags. Chromium forms silicates in acid slags, and while it is present in the form of chromic oxide in basic slags, apparently it does not combine with lime.

Averaging EXTENSOMETER

**QUICK
ACCURATE
LOW ZERO ERROR**



The H. F. Moore extensometer is ideal for determining yield strength, elastic limit and proof stress, as stipulated in Federal Specification QQ-M-151 a.

In addition to low zero error its large dial gage easily permits the reading of strains down to 0.00002 inch per inch of gage length. The gage is easily attached by screws which hold it firmly in position.

Adaptable to a wide variety of test pieces from 0.505 to 2 inches in thickness the H. F. Moore extensometer accurately averages strains on both sides of the specimen. Extension rods

quickly convert it from 2-inch to 8-inch gage length. Write for Bulletin 153-A describing Southwark's line of strain gages and extensometers.

Baldwin Southwark Division, The Baldwin Locomotive Works, Philadelphia; Pacific Coast Representative, The Pelton Water Wheel Co., San Francisco.

Baldwin Southwark



DIVISION OF THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA

Critical metallurgical operations

call for information

These metallurgical operations and problems have been vastly multiplied by War. They have created a crying need not for production equipment alone—but for helpful information as well.

Metal Progress has gone to the metallurgical readers themselves to get an exact and up-to-the-minute inventory on these metallurgical problems and requirements. Metal Progress is ready and eager to place this inventory in your hands, to help you get vital facts *out* of your files and *into* the hands of men on the war production firing lines.

This inventory of information is a compilation of many hundreds of specific comments, questions and problems gathered from readers themselves.

Why not take a fresh look at the metallurgical operations involved in metal working and metal production, and at the important part which metallurgical men play in this tremendous market. Let us show you the statements of the readers themselves. Let *them* tell you how and where and why your products and engineering information fit into their field.

With metals playing so vital a war-time role, the metallurgical engineer, the metallurgist—the metal expert, whatever his title—has an all-important voice today in war production—a voice that will be dominant in the post-war markets of the metal industries.

METAL PROGRESS

7301 Euclid Ave.

Cleveland, Ohio

Ferrous Metals
Non-Ferrous Metals
Engineering Applications
Conservation
Metal Working
Cleaning
Finishes
Welding
Heat Treatment
Testing
Inspection
Control
Melting
Casting
Mill Operations

May we prepare a comprehensive story for you, based on this inventory of last-minute information? You will find that it will pay you to cultivate this big industry through Metal Progress—tops in metallurgical circulation at 14,700 net paid.

METAL PROGRESS

7301 EUCLID AVENUE

CLEVELAND, OHIO

Tinning

(Continued from page 500)

exhibit "subnormal" or "difficult" tinning quality.

5. Articles and components which have been pressed or spun with the aid of lubricating compounds, and particularly those which have received interstage annealing, are liable to be "sub-

normal" or "difficult" in tinning.

6. Material which carries a residual film of drawing compound and has been held in stock for a long period may be "subnormal".

7. Steel wire may be "subnormal" or "difficult".

A common factor of the histories of the steels of "difficult" tinning quality is that they have been cold worked in the presence of lubricants and more

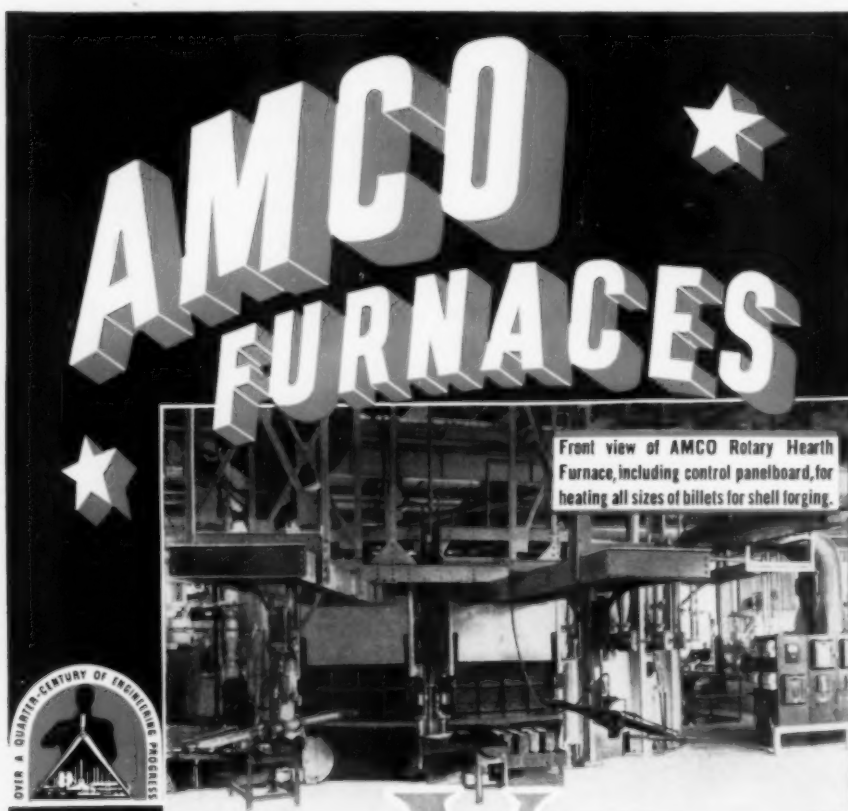
particularly that a subsequent annealing process has been undertaken without the removal of the lubricants.

For many years a procedure known variously as "grease-burning", "burning-off", or "flaming" has been used by tinnermen to improve the tinning quality of "difficult" steels. Generally the articles are heated in an oven or muffle furnace to between 300 and 900° C. The operation, however, will be successful only if the heat treatment is devised to suit the particular steel. Two actions take place: Residual grease and dirt are converted into more easily removable bodies, and the surface of the article is oxidized and is thus removable by subsequent pickling. These facts underlie the following recommendations for rectification by heat treatment:

As a preliminary, grease is removed by an alkaline detergent. The metal is then placed in a muffle furnace at a predetermined temperature, allowed to remain only for sufficient time for the whole charge to reach the working temperature, removed and allowed to cool. Loose scale is brushed off and the material pickled. It is then ready for tinning. (If the material is dipped in old pickling liquor prior to inserting in the furnace, a loosely adhering scale is produced. Much of this may be brushed off and pickling costs thus reduced.)

The correct temperature is determined as follows: The first trial is conveniently made at 1500° F. If de-wetting still occurs, the heat treatment temperature is raised to 1600° F. If, on the other hand, it yields a satisfactory coating, further trials may be made at successively lower temperatures until de-wetting occurs. If 100° F. steps are taken, de-wetting will normally arise quite definitely at one step. For production purposes, it is convenient to heat

(Continued on page 590)



Front view of AMCO Rotary Hearth Furnace, including control panelboard, for heating all sizes of billets for shell forging.



...are doing their part in America's Victory Program



AMCO Heavy Duty Furnace for large forgings; fired with Pulverized Coal; automatically controlled.

AMCO Continuous Charging, end-fired Slab-heating Furnace combined with AMCO Recuperator.



• The remarkable comparative production records being compiled by AMCO Ordnance Furnaces are truly significant. They mean that AMCO builds these furnaces up to the standard of its regular commercial equipment and not merely for a "quick turnover."

The new AMCO Principle and Method of "Artificial Loading" increases the efficiency, production and uniformity of all batch-type furnaces. Guns, tanks, armor-plate and other ordnance furnaces may be improved with this new AMCO principle.

If you are confronted with variables and losses due to non-uniform heating, put it up to AMCO!

The **AMSLER-MORTON** Company
MILTON BUILDING - PITTSBURGH, PA.





Portable Foundry Pyrometer with a Shock-Resisting Movement

Nearly every non-ferrous foundryman will agree that a reliable pyrometer is indispensable for the production of sound castings and lowest costs.

You want a rugged, durable pyrometer—one that will and can be given hard use—one that you can use anywhere either on the pouring floor or in the furnace room.

Heretofore, pyrometers sold for foundry service have too often proved delicate and fragile, requiring frequent attention and repairs.

Now, in the "Alnor" Pyro-Lance, is a pyrometer for molten non-ferrous metal temperatures that is rugged and shock-resisting.

The Pyro-Lance is a completely self-contained portable instrument that will help you lower costs by reducing scrap losses, cut your fuel consumption, improve your castings and speed up production.



Illinois Testing Laboratories Inc.

420 N. La Salle St.

Chicago, Ill., U. S. A.

SEE THE PYRO LANCE PYROMETER

ON DISPLAY

AT THE

FOUNDRY SHOW

CLEVELAND - April 20-24

Booth - 117

The Type 2981 Pyro-Lance is equipped with the enclosed thermo-couple, originally developed in the plant of the Ohio Brass Company and which has been improved and adapted to the Pyro-Lance. This thermo-couple is especially suited for molten brass, bronze, copper, aluminum bronze, magnesium alloys and similar metal where the temperatures are under 2250 degrees F. It should not be used for nickel, monel or other alloys where the temperatures exceed 2300 deg. F.

Not only is the life of this thermo-couple longer than bare wire thermo-couples, but because of its construction, it assures a reading at the tip of the thermo-couple. This enables a true reading to be taken below the surface of the metal unaffected by dross or surface conditions and immune to fluctuating readings.

Write for details

S. A. E.

**ALLOY
STEELS**

HY-TEN

OF AIRCRAFT QUALITY

Complete
Stocks at
BUFFALO
NEWARK
DETROIT
CHICAGO
CLEVELAND
CAMBRIDGE
CINCINNATI

Call on us for aircraft quality electric furnace steels S.A.E. 4140, X-4340 and S.A.E. 2330. Subject to Magniflux test, they conform to Army and Navy specifications. Hot rolled and cold drawn stock and forgings of all types can be shipped promptly. Write for folders giving properties of all our steels. Be prepared when you need steel in a hurry!

Wheelock, Lovejoy & Co., Inc.

Main Offices: 134 Sidney St., Cambridge, Mass.

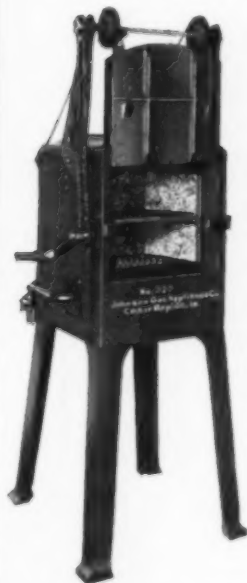
**New
JOHNSON
Furnace
ON THE OFFENSE**



to Speed Production!

No. 820 for Tempering and Drawing

Compact — Easily Moved



THIS new Johnson Furnace is definitely designed to take the OFFensive in speeding production. Use it for any job requiring 275° to 1200° F. . . . for tempering of tools, dies, small parts, non-ferrous castings and parts, for heating aluminum forgings and rivets! It's built to stand up under the most strenuous use, yet requires small floor space. Heavily lined with insulating refractory, and equipped with 2 large Johnson atmospheric burners, placed to give even heat thruout the combustion chamber. Self-aligning, counterbalanced door is well insulated to reduce heat loss, and is easily controlled by a crank. Two Allegheny metal shelves hold parts being treated. Firebox 16" wide, 16" deep, 14" high. \$450 F.O.B. Factory. Automatic temperature control available at extra cost.

Sales Offices:

Bourse Bldg., Philadelphia
120 Liberty St., New York City
C. B. Babcock Co., 475 11th St.,
San Francisco

FREE Full Information and
Catalog. Write—

JOHNSON GAS APPLIANCE CO. 561 E. Ave. NW.
CEDAR RAPIDS, IOWA

Tinning

(Starts on page 500)

treat higher than the temperature at which de-wetting arises.

Experiments quite clearly prove that de-wetting is a surface phenomenon, and not connected with the nature of the steel or variations in its chemical analysis or microstructure.

For instance, clean steel cold rolled to a very smooth surface in grease-free equipment tins in a normal manner, as does a freshly machined, degreased surface. Hence "difficult" steels may be rectified mechanically by removing the imperfect surface by shotblasting, sandblasting, grinding or filing. Very light treatment only is necessary. Care should be taken to avoid contamination of the

treated surface by oil or grease, since it may be found difficult to remove this from the absorbent rough surface. After the mechanical treatment the surface is degreased if necessary, lightly pickled, preferably in an inhibited acid bath, and is then ready for tinning.

The troublesome surface may also be removed by deep pickling. Sulphuric and hydrochloric acids are not found very suitable, because "over pickling" may supervene before the de-wetting tendency is overcome. Dilute nitric acid, however, under controlled conditions, gives the necessary smooth and rapid attack.

The following recommendations and precautions are offered:

The material should be degreased before deep pickling.

Rust and scale should be removed by normal pickling before deep pickling, since nitric acid does not attack these effectively.

Care should be taken to provide adequate ventilation of noxious vapors and spray.

The temperature of the acid should on no account be allowed to rise above 100° F. This will do much to minimize fuming. The rate of attack slows down appreciably below 70° F. and the recommended working range is 75 to 85° F.

Acid strength may be 10 to 25% by volume of 1.42 sp.gr. commercial nitric acid; the higher concentrations give correspondingly shorter pickling time. The minimum time consistent with good tinning quality should be used. Generally 25% acid will be found suitable, and 2 to 4 min. sufficient.

After deep pickling, plunge the metal into cold water and wash under strong jets or by vigorous swilling. If the material must be stored before tinning the storage tank water should be slightly more acid than usual, e.g. 2 to 4% HCl.



Easy Handling

MAINTAIN ACCURACY with JESSOP *tru-form* NON-SHRINKABLE DIE STEEL


The high resistance to distortion of Jessop TRUFORM is an effective answer to tool making labor shortage. TRUFORM can be used to advantage by both the unskilled worker and the veteran of the trade.

This non-deforming quality makes TRUFORM the ideal material for use on intricate tools and dies where resistance to distortion is a necessity. TRUFORM retains shape accuracy which eliminates expensive and time-consuming replacements before the tool or die is put into use. TRUFORM is easily machined — another important factor in reducing tool and die costs. Write for descriptive literature.


TYPICAL APPLICATIONS OF TRUFORM

Forming Dies • Blanking Dies • Drawing Dies • Lamination Dies • Burnishing Gears • Paper Knives • Milling and Form Cutters • Special Gauges and Master Tools • Punches • Taps and Reamers • Thread Rolling Dies • Press Tools of Intricate Designs • Screw Dies • Needle Swaging Dies • and for many other precision instruments or dies.

There is a JESSOP steel for every tool and die requirement.



JESSOP STEEL COMPANY
General Offices
WASHINGTON, PENNA., U. S. A.



JESSOP STEELS

FOR AMERICA AND HER ALLIES

CARBON • HIGH SPEED • SPECIAL ALLOY • STAINLESS • COMPOSITE STEELS